PLANTS AND HARAPPAN SUBSISTENCE:

AN EXAMPLE OF STABILITY AND CHANGE FROM ROJDI

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To Clare

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ABSTRACT

Plants and Harappan Subsistence:
An Example of Stability and Change from Rojdi

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Understanding regional diversity in Harappan Civilization, and the common elements that make up the Harappan Cultural Tradition, has been a major task of archaeology in South Asia. This dissertation contributes to this project through the examination of the plant portion of Harappan subsistence, about which comparatively little is known. Information about subsistence is important since it formed the Harappans' most fundamental relationship with their environment, and was the basis of their socio-economic system.

A palaeoethnobotanical project was designed for Rojdi, a Harappan site in Gujarat. Rojdi was inhabited during the Urban and Late Harappan Phases and its material culture contains both Harappan characteristics and regional variants. Analysis of findings from excavation, collection and identification of plant remains, and the study of the distribution of these remains throughout the site and in association with other archaeological features, led to the reconstruction of Rojdi subsistence for all phases of

occupation. The findings from Rojdi were then compared with the archaeobotanical record for all other South Asian sites of the Harappan period.

The results of the Rojdi palaeoethnobotanical investigation reveal that while some features of the general subsistence system remained unchanged, significant shifts in the plants and their distributions, chiefly in the form of altered dependence on existing taxa, can be observed throughout the occupation. These findings imply there was a broadening of the plant base and an intensification of plant-use strategies as the occupation advanced.

When compared with remains from other sites associated with the Harappan period, the Rojdi results bear out the perception that common elements of Harappan subsistence, namely the early establishment of a sophisticated cultivation strategy and diversification and intensification of subsistence strategies over time, co-existed with distinctive regional variation in the types of plants used and the expression of these general trends.

The paleoethnobotanical project at Rojdi was among the few in South Asia to have used advanced techniques of ecofact recovery and analysis. Its conclusions may be expressed as hypotheses about Harappan culture-wide uniformities and regional diversity in subsistence strategies that should be tested through implementation of similar projects in other sites.

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CHAPTER I. INTRODUCTION

The principal aim of this research project is to interpret the archaeobotanical remains at the site of Rojdi, in northwest India, with reference to diet and environment and within a socio-economic framework. By regarding human-plant interactions as essentially responses to both social and natural opportunities and constraints, a number of specific issues concerning Rojdi, the wider region of Gujarat, and ultimately the Indus Civilization as a whole, can be approached.

Paleoethnobotanical research in South Asian archaeological sites has in general been limited to noting the presence of archaeobotanical remains at particular time periods. As a consequence, little is known about how the distribution of plant remains changes through time at a particular site, or through the phases of evolution of Harappan culture as a whole (Vishnu-Mittre and Savithri 1982). No more than 70 sites in all of South Asia dating to earlier than 1000 B.C. have yielded plant remains of some form. Few of these sites contained more than a single taxon or represented more than an accidental find. Although the limited data base has hampered our ability to infer the occurrence and change of plant-usage patterns, it has by no means impeded the construction of theories or models which

attempt to explain Harappan subsistence. It is important to assess the status of our knowledge periodically, and examine critically the theories that have been developed which use this information. The most useful way in which to do this is to collect new data, most importantly data which includes differing portions of plant material at various levels of occupation within South Asian sites.

The collection of this data must commence at the level of the single site. A single site is an easily defined unit of analysis that is free of the ambiguities that presently plague our definitions of the Harappan Civilization, and its various sub-regions. The single site that is the focus of this dissertation is that of Rojdi, which, while being located in a peripheral region of the Harappan Civilization, namely Gujarat, has artifactual material which associates it with the "Harappan Cultural Tradition." Since it was occupied from the middle of the third millennium B.C. to the beginning of the second millennium B.C., which coincides with a critical period of transition of the Urban or Mature Phase to the Post-Urban or Late Phase, an in-depth analysis of the Rojdi subsistence system should add not only to our knowledge regarding this site, but also this region of Gujarat, and perhaps the Harappan Tradition in general.

A paleoethnobotanical research project at Rojdi was therefore developed, with its primary purpose the documentation of the inhabitants' utilization of cultivated

and wild plants, to examine variability and change in that utilization, to provide information on the habitat, and attempt to identify and differentiate all human and naturally induced changes occurring in the local environment during all phases of occupations. A secondary purpose was to examine the wider significance of the Rojdi data by comparing the Rojdi archaeobotanical record to material collected from other sites, and to attempt to account for the variability in the temporal and spatial distribution of plant remains. Apparent variability in archaeobotanical distributions from South Asian sites has already been utilized in theories dealing with plant origins and movements (e.g. Harlan 1976, Hutchinson 1976, Costantini 1979a), and related population and settlement dynamics (e.g. Possehl 1986, Jarrige 1985), as well as the evolution of region-wide subsistence systems (e.g. Allchin 1977, Possehl 1979:539, Ratnagar 1986), influence from areas outside South Asia (e.g. Sarma 1972, Possehl 1986) and differing plant-usage strategies among local populations (e.g. Weber 1988, 1989a). However, biases in the sampling and/or methods of analysis have not always been recognized. Critical examination of this data, along with the use of data from Rojdi, should lead to a better understanding of the human-plant interrelationship during Harappan times.

A further, subsidiary aim of this dissertation is to develop new explanations for plant occurrences and their

evolution in South Asian prehistory. These new explanatory models must be tested by future work.

The following chapters include attempts to address certain issues and answer some fundamental questions about subsistence and plant use at Rojdi and beyond. These include:

1. Description and interpretation of the Rojdi archaeobotanical record.

What plant taxa can be identified from the occupational (i.e. archaeological) deposits of Rojdi, what were their possible uses? What does their presence suggest about the condition of the local habitat and the types of environmental constraints imposed on the inhabitants? What does the proportional representation of each taxon suggest regarding the settlement, its subsistence strategy, farming practices, cropping seasons, water management system and human involvement itself? How do plant identifications compare to those from other sites of comparable age, and how well do they fit into existing theories about Harappan subsistence systems?

2. Description and interpretation of change in the Rojdi archaeobotanical record over time.

What changes in the Rojdi plant record can be identified during the phases of occupation of the site? What are the range of possible causes for changes occurring during the Rojdi occupation? Are dietary shifts or human-induced environmental changes indicated? Are the types of changes seen at Rojdi identifiable in other sites around the beginning of the second millennium?

3. Description and interpretation of the wider significance of the archaeobotanical material recovered at Rojdi.

Was Rojdi part of a regional subsistence system and does it reflect a common pattern of plant usage typical for Harappans or Sorath Harappans? What, if any, common elements are evident in Sorath Harappan diet regarding the inter-relationships between plants and animals, between wild plants and cultivated ones, and indigenous and non-indigenous species? What are the implications regarding interaction with other regions and peoples, and what is the significance and impact of both indigenous and non-indigenous cultigens on Rojdi and on the Harappan Civilization as a whole? What are the possible origins of the non-indigenous species and by what routes could they have entered South Asia and Rojdi?

The dissertation aims to propose and evaluate certain hypotheses. These include:

1. The variability seen in the rather limited archaeobotanical record from sites showing signs of Harappan traits has been used to interpret Harappan subsistence, farming practices, and changes in plant-usage strategies in ways which may be misguided owing to problems at the stages of data collection and interpretation.

2. Based on the utilization of systematic sampling procedures, the archaeobotanical record will eventually show that not only were a greater variety of both wild and cultivated taxa being exploited by the Harappans than is presently believed, but that many of these taxa were being used earlier than presently believed.

3. If a site spans the time period from the Urban or Mature Harappan period to the Late or Post-Urban Phase, its archaeobotanical record will display shifts in the diet that seem to correspond with shifts in the material record and settlement patterns.

The dissertation is laid out in a series of chapters, whose sequence is as follows.

Chapter II includes a description of the geographical extent and current theoretical status of South Asian

archaeology in order to situate the site and its region in the time period in question, and to orient the reader toward the problems addressed by this research.

The third chapter describes the applications and limitations of paleoethnobotanical analysis, establishing the framework within which the archaeobotanical remains can be understood. Chapter IV comprises a summary of the status of paleoethnobotany in South Asia and specifically focuses on the theories proposed concerning diet, environment, the origin and movement of various plant taxa, and subsistence changes.

Chapter V describes the study area. First, a general account of the environment is given, then a description of the site itself. The methods employed in the collection and analysis of archaeobotanical material from Rojdi are described in Chapter VI. Chapter VII includes the description of the recovered remains, their numbers and values, and human uses of these plants based on ethnographic sources.

The eighth chapter forms the bulk of the dissertation, namely the interpretation of the archaeobotanical remains discussed in the previous chapter. Here questions associated with the primary focus of the dissertation are addressed. Building upon the discussion in Chapter VIII, Chapter IX presents a model for Rojdi subsistence and plant procurement systems. Chapter X considers the wider significance of the

Rojdi data, corresponding to the secondary focus of the dissertation.

The final chapter summarizes my main conclusions, and presents a new series of questions which I believe should be addressed.

CHAPTER II. ARCHAEOLOGICAL PERSPECTIVES ON THE REGION

In order to adequately understand the site Rojdi and its temporal framework, a brief discussion of the prehistory and protohistory of South Asia is in order. This will not only give a cultural historical perspective to the research but will enable one to understand the significance of the questions being asked. Therefore, this chapter will present the prehistoric context in which Rojdi was inhabited, how Rojdi fits into existing schemes and theories of South Asian prehistory, where the inhabitants of Rojdi may have come from and what might have happened to them after the site was abandoned, what other groups of people may have been interacting with Rojdi, as well as which populations or sites are best suited for comparisons with Rojdi. To accomplish this task three subsections will follow: first a discussion of the current theoretical status of South Asian archaeology and the ways in which the prehistory of this region is best viewed, then a brief summary of the Harappan Civilization, followed by a more detailed outline of the archaeology of Gujarat.

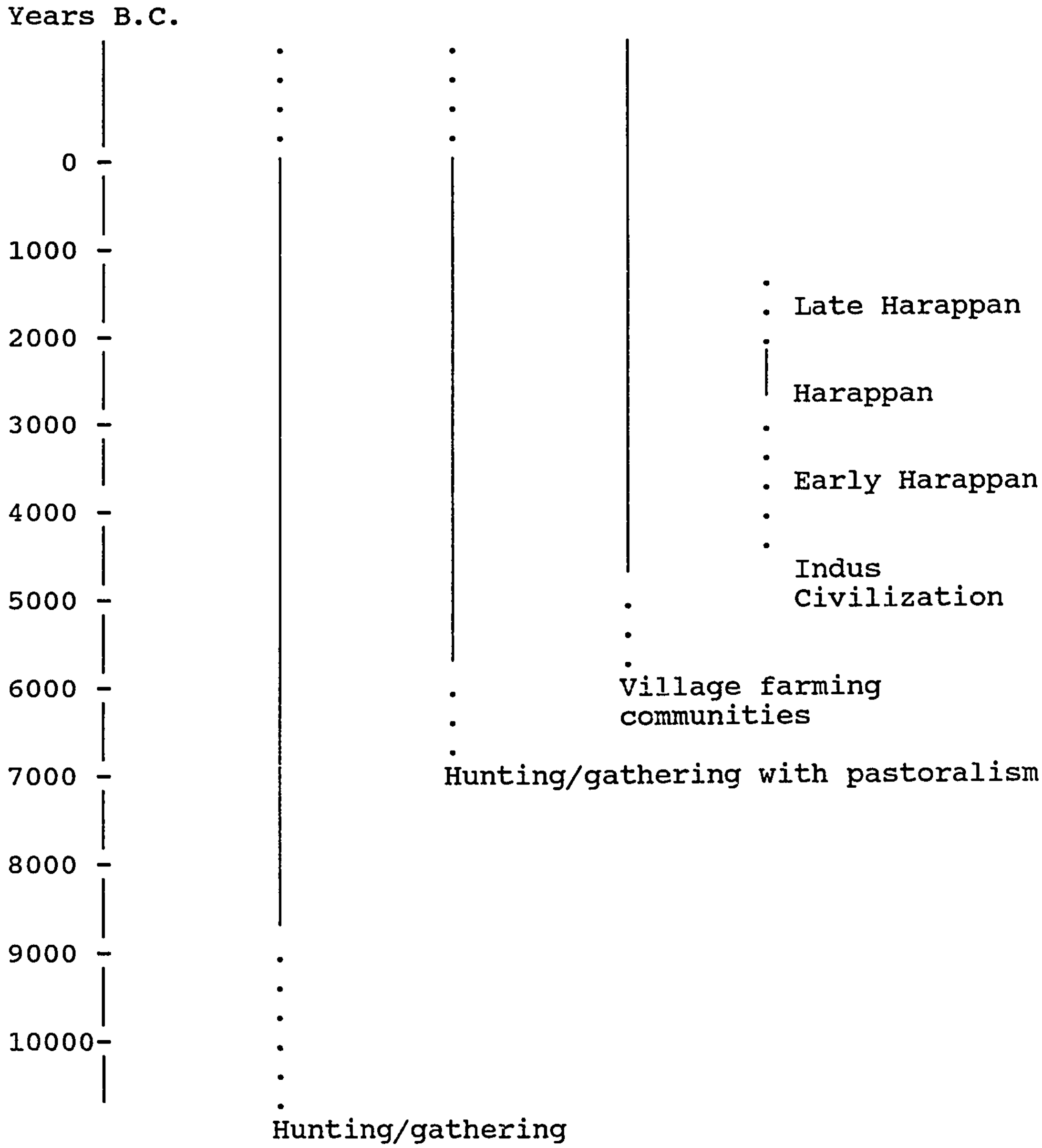
Status of South Asian Prehistory

Research into prehistoric and protohistoric South Asia has advanced from early concerns with the regional and sequential relationships of lithic assemblages and ceramics, and the projection of artifact typologies and technology through time, to to a more interdisciplinary approach oriented toward the reconstruction of past lifeways that operates with a more sophisticated and integrated concept of culture (e.g. Sankalia 1974, Allchin and Allchin 1982, Possehl 1982, Jacobson 1986). Many important archaeological discoveries in the last 20 years have expanded our basic knowledge regarding South Asian prehistory (Shaffer 1981, 1988:5; Agrawal and Kumar 1982). This is especially true in the area of the Harappan Civilization, where such work as Mughal's explorations in the Cholistan Desert have changed our understanding of Harappan settlement patterns (Mughal 1970, 1972, 1975, 1980, 1982, 1988). The interpretation of South Asian prehistory has been subject to much controversy, resulting from the limited number of excavated sites, the observed diversity in this limited data base, and the desire of many scholars to explain this diversity in terms of similarities to and differences from other regions of the world. Further, the frequent tendency to view the prehistory of South Asia as a single sequence of events, with each stage of development leading neatly into the next, has also caused

problems, since different regions developed at different rates and at different times, each interacting with, or being influenced by, other areas (Possehl 1976, 1980).

Simultaneous developmental and stylistic differences among sites, incorporating Neolithic, Chalcolithic, and Harappan Cultures, make up a pattern that is basic to South Asian prehistory (figure 1). Archaeological reconstruction implies the existence of similar but distinct groups of people in a common region, possibly interacting, yet maintaining different forms of economic adaptation (i.e. farmers, hunter-gatherers, pastoralists as well as groups using a combination of economic strategies) (Fox 1969; Agrawal 1982; Shaffer 1986; Possehl and Rissman In Press). Occurrence of archaeological sites with different forms of adaptation within a common region is often described as a "cultural mosaic" (Shaffer and Lichtenstein 1987:14; Possehl and Rissman In Press:45). In an effort to explain differences and similarities in the artifactual remains recovered from sites within a common region, Shaffer and Lichtenstein (1987:4) use the term "ethnic group." He uses it in a manner similar to that of "archaeological phase" (without applying chronological limits), where an ethnic group is characterized by archaeological assemblages in which one or more traits can distinguish it from other similarly conceived units (Shaffer and Lichtenstein 1987:4).

Figure 1. South Asian Chronology (adapted from Possehl et al. 1985).



Another approach, which focuses on artifactual similarities and utilizes the concept of "cultural tradition," identifies similar economic adaptations and technologies within a common temporal and geographic sphere (Possehl 1980, 1984). This concept has been used to facilitate stylistic grouping of diverse archaeological assemblages into a single analytical unit (Shaffer 1984:2). Further, it limits the need to establish the precise nature of cultural and chronological relationships that link assemblages, without denying that such relationships exist (Shaffer 1984). In contrast, where the ethnic group concept is composed of archaeological assemblages with one or more traits which distinguish it from other groups, the cultural tradition concept is composed of patterned sets of archaeological assemblages (Shaffer and Lichtenstein 1987:3).

As these different approaches show, the present trend in South Asian archaeology is to move away from unitary, linear models of evolution, and towards viewing sub-regions of Harappan Civilization in a manner which allows the researcher to explain the cultural diversity which is expressed in the artifactual record. Since most of the archaeological work in the northern portion of South Asia has focused on the Harappans or Indus Civilization, and since Rojdi was occupied during the time period of the Harappans and within the regional sphere of what is considered the Harappan Cultural Tradition, it seems appropriate that any

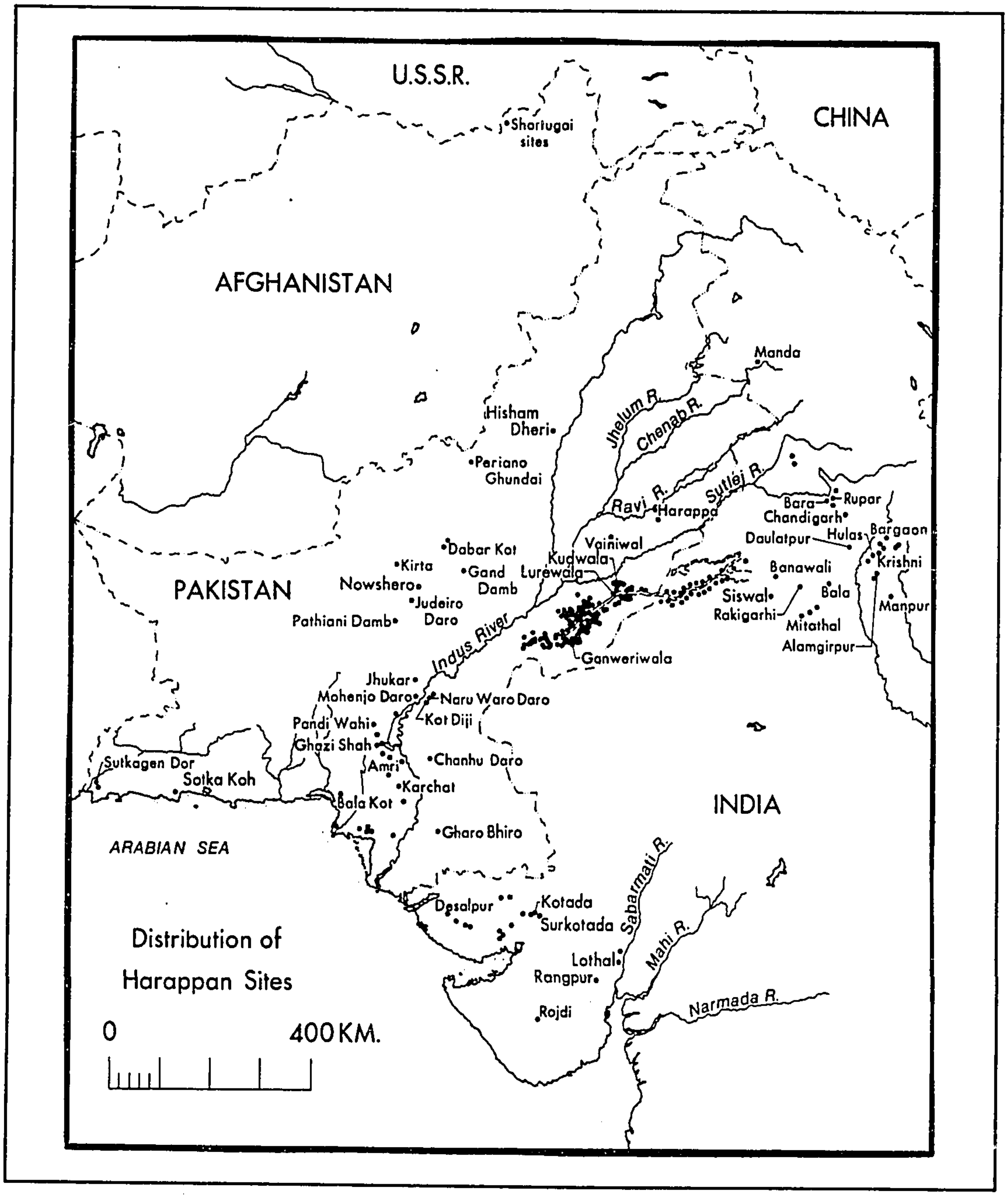
efforts to put Rojdi in some form of cultural and temporal framework should begin with a discussion of the Harappans.

Harappan Civilization

While most of what is known about the Harappan Civilization is based on the excavations of a few large cities like Harappa and Mohenjo-daro, the Harappan Cultural Tradition covered an area of around 300,000 sq mi (480,000 sq km) and includes hundreds, if not thousands of sites (figure 2). This geographical area is larger than that of contemporaneous civilizations of Egypt and Mesopotamia. Sites with Harappan-like artifacts can be found dispersed through an area extending from northern India, into Afghanistan and to the Iranian border.

Beginning with early seventh millennium farming communities like Mehrgarh (Jarrige 1984a, 1984b; Jarrige and Meadow 1980; Jarrige and Lechevallier 1979; Jarrige and Santoni 1979), this civilization experienced 4000 years of cultural development (Possehl and Rissman In Press:55). Their diversity notwithstanding, sites of the Harappan Civilization are best understood in terms of a single temporal framework. Therefore, a three phase approach using the terms Pre-Urban Phase, Urban Phase and Post-Urban Phase, developed by Possehl (1974, 1975, 1977), will be used here.

Figure 2. Map of Harappan sites (from Possehl and Raval 1989:4).



Encompassing Mughal's (1970:6) Pre-Early and Early Harappan Periods, Possehl (1979) developed the Phase "Pre-Urban" to signify the group of archaeological assemblages that presage the features which have become commonly associated with the Harappan tradition. The Pre-Urban begins with the initial development of food production in the Greater Indus Valley (around 7000 B.C.) and continues to the beginning of the Urban Phase around 2500 B.C.

Presently, the data suggests that the fusion of a number of different cultural groups occurring during the Pre-Urban Phase, including the inhabitants of Bagor, Hakra and Kot Diji, is the basis of what has become known as the Harappan Tradition (Shaffer and Lichtenstein 1987:12). While the Pre-Urban phase spanned some 4000 years, it was in the final 150 years of this phase, where we observe a rapid change which emerges into the Indus urbanization (Possehl and Rissman In Press:55). During this time a number of features or traits are evident that imply a development towards more sophisticated town life. These features include enclosing walls or fortifications, intensive agriculture, community planning, standardized brick sizes, metallurgy, increased settlement size, some styles of pottery and beads, and even some indications of long-distance trade and the beginnings of a script, can be found in the antecedent cultures scattered across almost as vast a region as that covered by the Harappan Tradition itself (Jacobson 1979:486).

While one or more of these traits occur in most Pre-Urban settlements, precisely how these regional traditions coalesced into a more culturally uniform civilization which includes cities, standardized town planning, etched seals, a uniform standard of weights and measures, and a form of writing, remains unknown. However, a number of conditions have been suggested which may have influenced this process. Shaffer and Lichtenstein (1987:12) have identified four causal conditions, including: 1. Changes in socio-economic organization which may have allowed for the expansion of crafts and trading activities; 2. A need to consolidate access to important geographical regions in a manner which would minimize conflict between competing social units; 3. Increasing interaction through competition for resources in the region, arising out of more stressful conditions; 4. A history of socio-economic interaction resulting from exploitation of a common region and facilitated by membership in a common cultural tradition. Other factors may have included a need for an organized response to flood disasters, which may have helped produce the types of administrative mechanisms that survive as regularities in the archaeological record (Gupta 1978; Jacobson 1979:486-487), or the impact or stimulus of long-range trade and commerce (Lal 1979:95).

While the conditions that led to the development of an urban civilization in the Indus Valley are subject to debate, the rapidity and the extent of this development is clear. [illegible]

is referred to as the Urban Phase (Mughal's Harappan Period), begins at about 2500 B.C. and lasts until around 2000 B.C. In the Indus Valley, (the core area of the civilization), this period is characterised by the full-blown development of urban centers such as Mohenjo-daro and Harappa. A distinctive constellation of artifactual and architectural styles are found at site after site throughout the Urban Phase. While these distinctive styles are different both from that which immediately preceded and followed this phase, they largely represent the culmination of a long process leading steadily toward the urbanization of the Indus Valley.

While some crafted items that were present in Pre-Urban sites increase in frequency, for example copper implements and stamp seals, other products like specific types of black-painted red pottery and etched carnelian beads appear for the first time during the Urban Phase. At the same time as this increase in industrial production, there appears a significant growth in the size of some settlements, with the occurrence of twin mound patterns taking place in many of the larger ones (e.g. Mohenjo-daro, Harappa and Kalibangan). Also found are examples of public architecture such as plazas, platforms, streets, multi-room non-habitation structures and hydraulic features such as drains, wells and tanks. The artifacts from Urban sites suggest a high level of technological sophistication implying a certain amount of craft specialization. The food economy seems to be based on

domesticated plants and animals, including wheat, barley, millets, rice, sheep, cattle, goats and water buffalo.

The Urban or Mature Phase is a period of expansion in which settlements with Harappan-like artifacts begin to appear in new regions, (e.g. Kashmir, Gujarat, North Afghanistan, the Makran Coast). The distribution of artifacts made from materials that were not available in the locality of these sites, (e.g. shells, stones, metals, and intrusive ceramics), as well as the occurrence of a common script, implies the existence of a trading system, and hence communication and interaction across space (Shaffer 1984:8). In sum, the essence of the Urban Harappan Tradition is contained in its script, the homogeneity of its material culture, and a certain degree of historical and cultural continuity.

The social and political systems underpinning the Urban Phase are still not adequately understood. The cultural complexity and homogeneity occurring within the Harappan Tradition does not fit existing models of ranked or stratified society. The lack of identifiable palaces, temples or exceptionally wealthy burials suggest that the Harappans did not develop a highly structured or centralized political economic organization based on hereditary elites (Shaffer and Lichtenstein 1987:13). In fact, the archaeological evidence indicates an absence of restriction

upon access to resources, and possibly the existence of non-material expression of status.

While the term "Urban Phase" has come to convey notions of city life, statehood and social differentiation (Possehl and Raval 1989:23), it should be understood that the absence of a political-economic organization based on hereditary elites makes the Harappan cultural system unusual. Although the Harappans are the best studied and most written about culture in South Asia, they were not the only cultural group in the region during this Phase. The wide range of artifactual and stylistic variation within the region influenced by the Harappan Cultural Tradition implies the existence of similar, but distinct cultural groups, who were simultaneously competing for resources and maintaining interaction networks (Shaffer's "ethnic group" concept). As might be expected, the Harappan border regions show an increase in local, supposedly indigenous traits, and a decrease in Harappan styles. A heightened degree of regional expression of Harappan traits, and a decline in urban life mark the end of the Harappan Urban Phase. The abandonment of Mohenjo-daro, Harappa, Kot Diji, Balakot, Allahdino, Kalibangan, Ropar, Surkotoda, and Desalpur, were all part of this process, although Harappan culture did not cease with the decline of major cities. The shift from the Urban Phase to the Post-Urban Phase (Late Harappan Period) at about 2000 B.C. did not occur at the same time, at the same pace, or in

the same way, in all regions of the Harappan tradition (Possehl and Raval 1989:28). While most of the artifacts recovered from the Urban and Post-Urban Phases are markedly different and indicate a shift in material culture, a number of artifact styles as well as some sites (e.g. Chanhudaro, Rangpur, Lothal, Bhagwanpura and Dadhur) can be found that span these two phases. The impression of continuity throughout the region as a whole is a strong one, suggesting that the Post-Urban phase be regarded as a part of the unfolding of Harappan culture and history, as opposed to something quite new (Possehl and Raval 1989:38).

In each region of the Harappan tradition, the processes of de-urbanization and growth of local styles take on different characteristics. In Sind, the region of Mohenjo-daro, the Urban Phase gives way to a the Jhukar complex. Jhukar sites include Chanhudaro, Jhukar and Amri, and have distinctive ceramics, metal objects and seals (without Indus script), weights, and terracotta cakes (Possehl 1980:10-16; Rissman 1985:89). The Post-Urban material from the region of Harappa and the Punjab is known as the Cemetery H Culture, notable for its glossy red-slipped pottery from funerary deposits adjacent to the mounds (Piggott 1962:235, Wheeler 1968a:70, 1968b, Mughal 1982:93, Rissman 1985:90). Changes in settlement patterns have been observed in other locations. For example, there is a decrease in the number of sites in

Sind, while at the same time, we see an increase in the number of sites on the Deccan Plateau.

Associated with this shift from large urban centers to smaller agricultural settlements are changes in the subsistence regime, observed by Jarrige (1985:35-68) in Baluchistan, by Shaffer (1986:195-236) in Haryana, and by Possehl (1986:237-256) in Gujarat. In each case, the subsistence shift takes on a distinctly local character.

The picture emerging of the Post-Urban Phase is one of limited retention of Urban Phase attributes in a broader context of de-urbanization, shifting settlement areas, and the development of new regional styles. Ceramics of the Post-Urban Phase fall into a category that is recognizably part of the Harappan tradition, but key features of Urban Phase ceramics are missing (Possehl and Raval 1989:24). On the other hand, the Indus script disappears altogether as an integrated writing system, although occasional graffiti-like signs on pottery are found (Possehl and Raval 1989:23). Triangular terracotta cakes, inscribed seals and large fired-brick structures also drop out of sight. Evidence for long distance trade and craft production, which is so prominent in the Urban Phase, decreases significantly in the Post-Urban Phase. Although the metal trade seems to continue as before, the increased occurrence of local craft styles suggests that the range of products and the distances across which they

were traded probably decreased in the Post-Urban Phase (e.g. Asthana 1976, 1982; During 1972).

The mechanisms responsible for this 'localization' of the material culture and the decline in urbanism are still not adequately understood. Explanations range from floods, invasions, water-logging of the soil, changes in climate, tectonic movements causing alterations in drainage patterns, to overgrazing and deforestation, yet there is presently no consensus as to which explanation, or explanations, best fit the data (e.g. Raikes 1965a 1965b, 1968a, 1968b; Dales 1964, 1968; Fairservis 1967, 1988, 1975; Flam 1981b, 1986; Gupta 1977a; Leshnik 1968, 1973; Miller 1985b; Mughal 1982; Possehl 1974; Rajaguru 1973; Shaffer 1988; Singh et al. 1974; Vishnu Mittre 1977,1983, 1978a, 1978b). What is apparent, regardless of the cause, is that the regional stylistic zones that comprise the material culture of the Post-Urban Phase indicate the presence of a cultural mosaic, much as was found in the Pre-Urban Phase.

The origins (e.g. Agrawal 1982; Allchin and Allchin 1982; Durrani 1981; Flam 1981a, Jarrige and Meadow 1980; Mughal 1970, 1982), characteristics (e.g. Fairservis 1967, 1975, 1988; Jocobson 1986; Kennedy 1982; Possehl 1974, 1982; Shaffer and Lichtenstein 1987;), environment (e.g. Agrawal and Sood 1982; Agrawal and Pande 1977; Agrawal et. al 1980; Allchin and Goudie 1978; Bryson and Baerris 1967; Hegde 1977; Singh 1971), chronology (e.g. Dales 1973; Jarrige 1984a;

Possehl and Rissman In Press; Sankalia 1974;), trade (e.g. Fentress 1976; Ratnagar 1986;), decline (examples listed above) and subsistence (e.g. Allchin 1969; Burnham 1980; Chowdhury 1965; Costantini and Biasini 1985; Fentress 1984; Hutchinson 1974; Meadow 1984; McKean 1983; Mehta 1984; Ratnagar 1986; Vishnu Mittre 1972b, 1974, 1978, 1982), of the Harappan civilization are still controversial subjects despite considerable research into the nature of Harappan culture. Interpretations of its political organization range from Piggott's (1950) conceptualization of a state ruled by priest-kings, to Shaffer's (1982) model of an urban culture without hereditary elites or centralized government, or to Fairservis (1988) model for a chiefdom. Such marked diversity of interpretation can be found in most topics concerning the Harappan tradition (Jacobson 1986:137-173). In border regions like Gujarat, where local styles and more traditional Harappan attributes are found mixed together, reconstruction of society in the second and third millennium B.C. is perhaps more difficult.

Gujarat Pre-History

Aside from Sind and Punjab, a third region of Harappan influence is the area approximately coterminous with the modern state of Gujarat (Possehl 1980:18). A detailed description of the physical environment of the four regions

of Gujarat (Kutch, Saurashtra, North Plain, and South Coast) will appear in Chapter V, "The Study Area". The following discussion will focus on the archaeological record of the region.

While Gujarat may be seen as a peripheral or border zone of the Harappan Tradition, its material culture displays independent regional styles with more traditional Harappan-like styles, suggesting the coexistence of Harappan settlements and local indigenous occupation. Although not all the sites which are relevant to the discussion of Gujarat during the third and second millennium b.c. are Harappan, Gujarat is within the regional sphere of what is considered to be the Harappan Cultural Tradition and will therefore be discussed within the only temporal framework available for this region, that of the Pre-Urban, Urban and Post-Urban Phases. It should also be noted that a long tradition of Harappan influence can be documented at sites in Gujarat (e.g. Rangpur, Surkotada and Lothal) whose material culture and town planning is similar to that of the Indus Valley Civilization.

The Pre-Urban Phase in Gujarat is poorly understood. While there is little evidence for early Harappan styles in this region, there is evidence for non-Harappan Pre-Urban occupation. Indigenous hunting and gathering populations undoubtedly inhabited Gujarat prior to the occurrence of Harappan settlements. The Pre-Prabhas Period at Somnath may

document the beginning of village based, food producing economies in this region (Possehl and Rissman In Press:82). While the ceramics from the Pre-Prabhas Period are not Harappan in style, they do show some "affinity" in vessel form and fabric with those of the Harappans (Possehl and Raval 1989:16).

It is not until the Urban Phase, when the Harappans probably came to Gujarat in an effort to gain access to certain raw materials, that Mature Harappan sites are found in the region. Excavations at Rangpur (Rao 1963), Lothal (Rao 1973, 1979), Surkotada (Joshi 1972a, 1972b, 1976, 1979), and Desalpur (Soundara Rajan 1980, 1984) have shown that material remains such as inscribed seals, ceramics, metal work and beads, which are typical of the Urban Phase Harappans, were part of the material culture in Gujarat by about 2400 B.C. The Urban Harappans migrating to Gujarat were exposed to, and interacted with, the local indigenous inhabitants of the region. At times this interaction may have been hostile, as implied by the presence of walls often found surrounding the settlements. The sites of Surkotata, Lothal, and Rangpur typify the range of urban centers in Gujarat.

Surkotada, located in Kutch, is a small site with an encircling wall up to seven meters thick (Joshi 1972a:120). The ceramics are the typical Harappan Black-on-Red painted ware. Other artifacts include lapis, carnelian, faience and

steatite beads, terracotta seals with protographic script (without animals), copper rings and bangles, and a large heavy celt. There are no indications of a previous occupation below the earliest Mature Urban Harappan occupation. The cultural deposits (ca. 60 m by 120m in extent, and from 5 m to 8 m in depth) have been divided into 3 phases (1A, 1B and 1C), each of which with a number of different structural phases (Joshi 1972a, 1972b). Based on calibrated radiocarbon dates, Surkotada was probably occupied between 2200-1900 B.C.

Lothal, a site of about 6.5 ha, is located along the alluvial neck bridging Saurashtra and North Gujarat. The settlement of Lothal was nearly rectangular with a massive, encircling brick wall. Its specialized architectural features included an "acropolis", "dockyard", a warehouse or granary, bathing platform and drains (Rao 1971, 1979). These terms were applied to the structures by the excavator and may not represent their actual function. In other portions of the settlement, streets, residential areas and industrial activities such as copper smelting, shell working and bead manufacture have been identified (Rao 1973:68). Based on the type of artifacts recovered (including ceramics and terracotta seals), the public architecture and settlement layout, and the type of craft specialization, Lothal can be seen as an Urban Harappan settlement with strong ties to the Indus Valley. Occupied between 1900 - 2400 B.C., Lothal

represents the best evidence we have for a Harappan occupation in Gujarat. It was probably involved in trade and in efforts to gain access to the raw material wealth of the area.

Rangpur, another site in this cluster of Urban Phase sites in Gujarat, is located just south west of Lothal. Rangpur is one of the main sources for a ceramic chronology developed for Gujarat. The ceramic record from this site displays regional and Harappan characteristics. The multiple levels of occupation imply Rangpur was inhabited from about 2500 to 1400 B.C. (Rao 1963). This site is best seen as an Urban and Post-Urban Phase settlement, whose material culture contains both regional and Harappan influences. The "Harappan Tradition" in Gujarat is exemplified by the chronological and cultural continuity represented in the three phase sequence at Rangpur (Possehl 1979, Possehl and Raval 1989:7).

With the additional information from excavation at the site of Rojdi, a new picture is beginning to emerge regarding the Harappans in Gujarat. Rojdi was occupied between 2500-1800 B.C. and therefore clearly encompasses the Urban Phase. Yet the material recovered from the site is not the Mature Harappan material found in sites like Lothal and Surkotada, which are of comparable age. Rojdi may be one of several sites in Saurashtra that exemplify a regional expression of the Harappan Urban Phase. The term "Sorath Harappan" has

been coined to describe them (Possehl and Herman In Press). The Sorath Harappan, while part of the larger cultural tradition, is a regional manifestation of the Indus Urban Phase which is stylistically divergent from the Harappan Tradition seen in Urban Phase sites in Kutch, Sind and Punjab.

The picture emerging from the Urban Phase in Gujarat is one which includes indigenous hunters and gatherers, settled villages and towns, and Harappan populations migrating into the area. Mature Harappan settlements like Lothal, where manufacturing and commercial activity far outstripped the needs of the inhabitants, (Possehl and Raval 1989:20) support the idea that trade was a major stimulus of Harappan immigration. Other sites like Rojdi and Rangpur show the importance and influence of local styles over Harappan ones. Once again, a mosaic view of interconnecting and interacting cultures emerges as the most plausible way to view Gujarat in this period.

The decline of Mature Urban Harappan settlements and the onset of the Post-Urban Phase in Gujarat is comparable in many ways to the rest of the Indus Civilization. The material culture that is specific to Gujarat, as well as the more classical Indus styles, undergo a period of change as the Urban Phase ends. Ceramic trends include alteration in shape and decoration, and an increase in frequency of Lustrous Red Ware (pottery which has been burnished to a high

lustre). A decline in urban life can be seen at Lothal at the onset of the Post-Urban Phase, at which time public areas (e.g. the dockyard and acropolis) fall into disuse (Rao 1979:111). Artifacts such as steatite stamp seals, chert weights and terracotta cakes decrease or disappear in Gujarat as they do in other regions of the Harappan tradition. Later periods of occupation at Rojdi and Rangpur are termed labeled early Post-Urban, and show signs of a decreased frequency of Harappan styles.

Examples of the Post-Urban occupation occur south of Gujarat on the Deccan Plateau, and conform to what is known about the Harappan Tradition in Gujarat. The site of Daimabad, with its mud brick construction, single terracotta seal and potsherd with an Indus inscription (Sali 1982, 1986), and red ware ceramics like those from Rangpur IIB or IIC (Possehl and Rissman In Press:75), is like a Post-Urban Harappan Tradition settlement.

In Gujarat, the Post-Urban Phase ranges from 2000 to 1400 B.C. and is commonly regarded as involving a movement toward small-scale villages with simple architecture. The deterioration of large metropolitan centers, accompanied by a decline in the integrated systems of control and regulation, and the socio-economic system with which they were associated, could have affected the inhabitants of regions like Gujarat in significant ways. Demand for certain foods and material goods, which were closely associated with

the interactions between the Indus Valley and Gujarat, may have been radically altered or removed altogether (Possehl and Raval 1989:21). As in other regions influenced by the Harappans, the Post-Urban Phase in Gujarat sees an increase in local styles at the expense of all other styles derived from the outside.

Gujarat is a critical region in which to study the Harappan Tradition, its sites being of particular value in the investigation of border regions, the emergence of the Post-Urban Phase, trade between the Indus region and other regions, local integration of various economic systems (hunting and gathering, pastoralists, agriculturalists) which is so typical of the cultural "mosaic" in South Asia, and finally, the eventual decline of the Harappan Civilization.

Chapter III. PALEOETHNOBOTANICAL ANALYSIS

In order to fully understand the design and implementation of this research project, it is necessary to examine the development, applications and limitations of ethnobotanical research. The following discussion commences with a historical view of ethnobiology, and concludes with an assessment of the role of archaeobotany in archaeology.

Historical Account of Ethnobiological Research

Ethnobiological research can be described as work that draws on both biology and anthropology to make statements about the interrelationship between living organisms and human culture, whether prehistoric, historic or contemporary (Weber 1986). Interest in this interrelationship is not new. Ever since anthropologists' initial emphasis on natural history, biology and anthropology have been intertwined. For example, there were the early attempts by anthropologists to classify societies on a scale of evolutionary development according to their mode of subsistence, where the appropriation of nature was regarded as critical factor in determining the advancement of other aspects of culture (e.g. Morgan 1877; Forde 1934; White 1959). Later studies focused on the systematic relationship between a sociocultural entity

and its environment, and stressed adaptation and change in ecological systems (e.g. Steward 1955; Ellen 1982). More recently, interest in the development and spread of cultigens, domesticated animals and agricultural complexes, and their co-variation with social organization and population have all helped to stimulate interest and research in the interrelationship between biology and anthropology (e.g. Sauer 1952; Boserup 1965; Higgs and Jarman 1972; Flannery 1973, 1986; Harlan and de Wet 1973; Cohen 1977; Reed 1977; Iltis 1983; Rindos 1984).

One aspect of ethnobiological research is of interest here, that of applying knowledge of both botany and anthropology to the study of archaeological plant remains (Pearsall 1989b). The study of plant remains derived from archaeological contexts have been entitled "paleobotany", "archaeobotany", "archaeopaleobotany", "ethnobotany", and "paleoethnobotany". The term "ethnobotany" has the greatest time depth and has the broadest usage, although there has been effort by some researchers to differentiate the meaning between these terms (Ford 1978a, 1978b). For example, Ford (1979) has suggested that archaeobotany refers to the recovery and identification of plants while paleoethnobotany refers to their interpretation. The word first appeared in the work of J. W. Harshberg (1896), a botanist at the University of Pennsylvania, who defined the term broadly as

the study of the plants used by primitive and aboriginal people (Ford 1978a).

The first ethnobotanists are generally agreed to have been Europeans of the nineteenth and twentieth centuries, who analyzed plants recovered from contexts remarkable for their excellent preservation, such as Pompeii, Egyptian tombs, Swiss lake dwellings, and the arid Peruvian coast (Ford 1979). Early ethnographers in North America displayed a keen interest in natural history, and elements of both ethnology and botany were brought to bear on the gathering of data from contemporary people. Thus, ethnobotanical research in the United States before World War II comprised many lists made by ethnologists, botanists and explorers of the plants used by indigenous peoples (Ford 1979; Bye 1985). However, as Ford (1979) states, there was comparatively little archaeological data, with the exception of a few studies including the identification of charred plant remains from Bawn Village in Ohio (Mills 1901), the analysis of plants in human feces from Salts Cave, Kentucky (Young 1910) and attempts to collect plants in Northern Arizona (Kidder and Guernsey 1919). With the development of dendrochronology in the 1920s, environmental reconstruction became more sophisticated and more valuable to archaeologists (Fritts 1966). Since the 1930s, ethnobotanical data has played an increasingly important role in archaeological investigation. The work of Melvin Gilmore and Volney Jones, the setting up

of the Ethnobotanical Laboratory at the University of Michigan, and the influential multidisciplinary projects of Braidwood (Braidwood and Reed 1957), MacNeish (1961) and Clark (1954), have all helped to establish ethnobotany as a widely practiced, accepted, and indispensable element in archaeological research (Ford 1979).

Gone are the days when botanists would be asked to simply contribute their expertise to the identification of plant remains derived from archaeological contexts ("laundry lists") without being expected to have any great insight into the research orientation as a whole. Nowadays, it is more usual for specialists to take an active role in model and hypothesis building that blends methods, concepts and models drawn from both anthropology and biology.

Paleoethnobotany and Archaeology

Paleoethnobotany has become an important part of anthropological archaeology. Studies of living peoples suggest that plant remains recovered in archaeological sites are either a by-product of specific human patterns of behavior and/or due to accidental plant inclusions from the local habitat (Ford 1979, 1985; Butzer 1971a). Plants are not selected randomly, they are named, classified, collected and used, according to rules and beliefs associated with each culture. While in an archaeological context ethnobotanists

deal with plant remains that offer limited insight into beliefs and values, these remains can be used to reconstruct some aspects of the cultural and natural environment (e.g. Hillman 1975, 1981, 1983, 1984; Flannery 1986; Thomas 1983a, 1983b).

Cultural anthropology has traditionally furnished models for how and why plants may have been used in prehistory (Ford 1985a, 1985b, 1985c). However, recent ethnographic studies have shown that people are not necessarily aware of the consequences of their behavior, and so it appears that ethnobotanists cannot rely solely upon the testimony of informants in order to reconstruct plant usage systems. Linguistic analysis can assist by drawing out implicit meanings associated with plant utilization (Shaul 1983). On the other hand, a specifically biological approach stresses the botanical aspects of the impact of human behavior on plants, thus providing a counterbalance to those studies that are predominantly weighted toward the study of cultural implications, as well as emphasizing the concept of interaction in human-plant relationships (Rindos 1984). Experimental studies may also help to determine physiological and anatomical responses of plants to environmental and human influences (Schuster and Bye 1983).

The systematic analysis of plants and plant parts from carefully secured proveniences in archaeological sites can provide evidence for ancient environments, diet, economy, and

generally increase our understanding of human utilization and interaction with plants. On a more abstract level, one can infer information about the process through which plants collected in the natural environment enter the social system and finally pass into archaeological deposits (Miller 1982:126).

The resource role fulfilled by plants reflects the plant's physical and biological properties as well as the human needs generated by the physical, biological, social, and politico-economic realities of their local ecosystem (Alcorn 1984). These needs include biological needs of the individual and community, as well as cultural needs, both of which vary over time. Change in sociocultural conditions can alter the human-plant interrelationship. Thus ethnobotany can be used to help understand cultural changes that articulate with the botanical environment.

Because plants appear prominently and in a range of use-contexts in human societies, the application and achievements of ethnobotanical studies using archaeological remains have included the following: the elucidation of artifact function (e.g. Briver 1976); description of subsistence similarities and differences of major occupations in a site (e.g. Yarnell 1964; Johannessen 1989); ascertaining specialized subsistence activities correlating with certain rooms and parts of a site (e.g. Hill and Hevly 1968); examining botanical evidence for clues to site abandonment or re-

occupation (e.g. Bohrer and Adams 1977); determining medicinal and ceremonial plant uses (ibid.); developing a calendar related to probable seasonal plant procurement in an area, and describing the habitats most likely to be exploited (e.g. Winterhalder and Smith 1981; Bye 1984; Jochim 1976); understanding the human modification of the local environment around a site (e.g. Minnis and Ford 1977; Lewis 1981; Smart 1989); the construction of climatic chronologies, and determining the nature, magnitude and duration of climatic perturbation, relating this specifically to human demography and subsistence strategies (e.g. Euler et al. 1979); development of models dealing with farming techniques and plant domestication (e.g. Shuster and Bye 1983; Hastorf 1989); understanding nutritional requirements and projecting how these might have been satisfied with different combinations of plants (e.g. Wetterstrom 1976, 1978; Wing and Brown 1979); and finally, the exploration of migrations, trade, and social intercourse (e.g. Pickersgill 1972; Minnis 1985a 1985b).

In order to interpret ethnobotanical data in the ways described above, a number of anthropological and botanical considerations, as well as bridging arguments should be acknowledged. Plant remains come in a variety of shapes and sizes, and may possibly be burned. They range from microscopic pollen grains, spores, and phytoliths (plant microfossils) to clearly visible items such as seeds, twigs,

stems, nuts, and fibers, or pieces of wood (plant macrofossils). Archaeological seeds, which constitute only one category of plant remains, are the focus of this research, and so the discussion will now focus on the processes of deposition and preservation of seed remains, and their possible archaeological significance. Seed occurrences in archaeological contexts can come about as the result of a number of different events and processes, for example, the direct prehistoric use of the seeds, as a by-product of the use of another part of the plant, by incidental inclusion in a different resource such as dung, by natural dispersal where accidental preservation may occur without the benefit of human intervention, and finally, by means of recent contamination (Minnis 1981:145). The term "seeds" will be used here in its popular or general sense, and includes botanical fruits such as achenes or caryopses.

While seeds have been collected from archaeological sites for some time, up until recently seeds were found only when they occurred in sufficiently large concentrations to be visible to the naked eye during excavations (Spector 1970). The development of new techniques, especially flotation, enabled the routine recovery of a large range of seed taxa from a variety of contexts, including seeds which were not visible during excavation. Since Struever (1968) popularized the flotation technique, large numbers of seeds have been recovered from large volumes of soil in

archaeological sites. Dry screening is used in place of flotation when the archaeological seeds are likely to crumble on contact with water.

In order for seeds to be preserved in the archaeological record, normal decay must be slowed in some manner. The most common means of seed preservation are charring or mineralization (Green 1979). Uncharred seeds are generally considered to be modern contaminants, although some seeds are extremely durable and under certain conditions may be preserved (Keepax 1977; Schaaf 1982:221). Further complicating analysis is the fact that many of the seeds found in the archaeological record are not prehistoric, and need to be segregated from the prehistoric ones. Keepax (1977:225) has identified four sources of contamination: 1) careless excavation, sample collection or flotation; 2) aerial contamination of exposed samples; 3) cross-contamination in the flotation apparatus; and 4) contamination of the soil prior to excavation through such means as ploughing, root holes and drying cracks in the soil, downwashing, and the burrowing of insects or animals. Careful excavation techniques, and familiarity with the ways in which seeds become embedded in archaeological soils, are indispensable for distinguishing prehistoric and recent plant remains. In addition, radiocarbon dating of the seeds themselves, finding relatively high concentrations of seeds sandwiched between layers with few seeds, comparing the

archaeologically recovered seeds with those collected from nearby non-archaeological soils, contrasting the size and morphology of cultivated grains with their wild relatives, can all assist in segregating archaeologically relevant seeds from recent contaminants (Keepax 1977:225-226).

The most widely accepted criterion for the antiquity of seed remains is carbonization, which occurs when seeds which have been burned in the absence of oxygen are reduced chemically to carbon. It is often a simple matter to reject all uncharred seeds as modern in origin and to retain only charred material as genuine (Keepax 1977:226). Ordinarily, unless there is reason to believe otherwise, only charred remains are considered prehistoric (Minnis 1981:143). However, seeds can become carbonized naturally (e.g. naturally caused fires). If no charred seeds are recovered from the non-archaeological samples around the site, as is the case with Rojdi, then it is probably safe to assume that all charred seeds are prehistoric. Once modern seeds have been separated from their prehistoric counterparts, it is important to determine the prehistoric processes by which seeds become carbonized. The two most common ways for this to occur in an archaeological context is either intentionally (e.g. fuel), or by chance (e.g. food remains) (Miller 1982:93).

The uses of a plant will clearly affect its chances of occurring in the archaeological record, since those seeds

which come into contact with fire are more likely to be preserved. Since food is generally meant to be consumed and not carbonized, if carbonized seeds found in archaeological contexts do represent food and not some form of indirect intentional burning such as dung-cakes for fuel, or due to such unusual circumstances as a settlement being destroyed by fire, then carbonization is usually caused by some accident such as scorching in a parching oven, spillage by the hearth or singing in some manner during its use (Renfrew 1973:21; Dennell 1976:233). Activities in which plants are involved that require heat or occur around fires are more likely to lead to carbonization, and hence preservation. Therefore plants which are crushed for juice, dried for later use, or plants consumed in a fresh state such as roots, greens, fruits, and nuts are less likely to be preserved in an archaeological site than seed plants that are parched, cooked or processed in close proximity to fires.

The physical characteristics of a plant can also affect its chances of being preserved. All things being equeal plants which produce few large seeds are less likely to be preserved in large numbers than plants which produce large numbers of small seeds. Plants in such families as Chenopodium or Amaranthus which produce thousands of seeds per plant are more likely to be represented in the archaeological record than nuts or single seeded fruits like plums. Furthermore, seeds are not equally hardy to various

environments and their breakage patterns as well as their processes of decay differ.

If the context for the use of each plant is culturally prescribed, and if the associated artifacts and resulting plant debris reflect that activity, then ethnobotanical remains may have cultural significance, if, and only if, a number of limiting factors can be accounted for, or at least understood to some degree. The limitations of ethnobotanical research fall into several distinct categories. First, our knowledge of the differential seed production rates of plants, mechanisms of dispersal, likelihood of preservation and modes of accumulation in the prehistoric context remains partial at best. Second, there are methodological problems to be overcome concerning techniques of collection, separation and identification of remains. Third, there are difficulties associated with the use of ethnographic analogy, theories of spatial organization, and the assumption that a correlation exists between the ongoing human-plant relationship and the products of that relationship which exist in the archaeological record. Finally, problems and difficulties beset the reconstruction of patterns of prehistoric plant use. If the prime goal of paleoethnobotanical studies is the reconstruction and understanding of past human-plant interrelationships, then one of the major sources of evidence for this task is analogy. Since events in the prehistoric past cannot be

directly observed and archaeologists can only reconstruct past societies from the material record, and moreover, if there is a desire to go beyond mere description, archaeological interpretation needs to be based on some kind of analogy -- namely, the understanding of non-observed behavior from observed behavior (Hodder and Orton 1976; Hodder 1983,). Paleoethnobotanical studies, like all archaeological studies, need to recognize the limitations of applying ethnographic data to the interpretation of prehistoric events, but its utilization in the construction and testing of analogies, hypotheses and models has become a useful and, perhaps, unavoidable part of archaeology (Dennell 1972).

It has to be understood that the seed record in an archaeological site is highly biased and an incomplete reflection of that once living community. Only a small portion of the seeds will be carbonized, a smaller number will preserve, and a smaller number still will be retrieved in excavation. We must also beware preconceived notions about people, plants and their interactions. Categorizing plants as domesticated or semi-domesticated, wild, weed, or cultivated or semi-cultivated, can pre-empt our attempts to understand the specific relationship with plants that prehistoric populations enjoyed. By definition, these categories contrast dependent, field grown crops (domesticates) with their undesirable companions in the field

(weeds) (Harlan and de Wet 1973). Domesticates and weeds are contrasted with those untended plants growing in disorder beyond the controlled area -- the wild plants. The term semi-domesticated refers to a plant undergoing the early stages of domestication or "incipient domestication" (Bye 1979). In those situations where plant remains do not fit these preconceived categories, as is more often the case than not, the common response is to restructure the data, and the categories are misused. Moreover, the tendency with these categories is to conceptualize plant utilization and manipulation in a progressive and diachronic fashion (Alcorn 1984).

In order to compensate for these problems and limitations, a methodological and analytical framework must be developed which logically and consistently relates archaeologically recovered seed remains to human activities, and ultimately to society. Like all archaeological data, the meaning of ethnobotanical data must be based on inference, since archaeological materials are static and society and behavior are dynamic (Miller 1982:139). Like artifacts, seeds can be identified, their spatial and temporal distribution can be determined, and the uses of these seeds can be inferred. Also, as with artifacts, the quantity and distribution of seeds recovered in an archaeological site are not necessarily proportional to their use or importance in their economic system (Dennell 1976:16). Yet, by using a

variety of bridging arguments and by using as many lines of evidence as possible, plant data can be made to yield archaeological interpretations or understandings about specific plant interactions (e.g. Crabtree 1982; Kadane 1989; Toll 1989).

Studies dealing with human uses of plants or with the adaptation of plants to human intervention should be performed with a clear understanding of the basic principles behind human-plant interrelationships. There is a need to consider both human and plant variables. For plants, one would need to take into account the type and part of the plant being used; the region, climate and environment in which it is found; its abundance, variability and distribution; the season in which it could be collected and used; and its nutritional value and the ease with which it can be exploited (Bohrer and Adams 1977; Hevly 1981; Gasser and Adams 1981). The human factors in this relationship would be population size and distribution; plant preferences based on taste and social value; the variety of resources in the diet; the population make-up in terms of age and sex; the level, type, and range of trading patterns; and finally, the state of technology.

A problem-oriented research design, an adequate sampling procedure, the use of quantitative methods of analysis and the using of botanical, ethnographic, historical, and ethnoarchaeological sources, form the basis of a testable

archaeological interpretation of the botanical data. Results should be capable of being used in the construction of models to explain human-plant interrelationships. The processes by which archaeological plant data may be used in the interpretation of human-plant interactions at a specific location at a specific time period, will become evident in subsequent chapters of this work, where the Rojdi data set is analyzed and interpreted.

Chapter IV. STATUS OF PALEOETHNOBOTANY IN SOUTH ASIA

The paleoethnobotanical study of Rojdi must be set against the broader archaeological context, as well as current paleoethnobotanical knowledge in the region. The current chapter aims to sketch the history and nature of our knowledge about prehistoric plant use in South Asia.

The systematic analysis of plants and plant parts from carefully secured proveniences in archaeological sites is beginning to increase our understanding of the prehistoric South Asian inhabitants' utilization of local flora and their relation to the environment. Yet studies in South Asia which focus on the relationship between plants (their occurrence, location, density and morphology) and other cultural remains (artifactual and structural) in the wider context of social and environmental constraints, and in view of taphonomic processes, are rather limited. At the time of writing, no more than 80 sites in all of South Asia dating to earlier than 1000 B.C. have yielded plant material of some form. While the lack of plant remains in South Asian sites may be attributed to poor preservation factors or methodology, it also reflects the limited number of sites excavated and the relative unimportance of botanical analysis for South Asian archaeology.

Although our knowledge of human-plant interrelationships and paleoethnobotanical reconstruction is not limited to the recovery of archaeobotanical remains, it is difficult to understand dietary patterns and plant use strategies without such data. At present, even with linguistics studies, modern morphological and genetic comparisons, and artifact and settlement pattern studies, the actual status of our knowledge regarding South Asian paleoethnobotany is limited to simple statements of presence or absence of plants at particular sites. Although a number of scholars have been successful in their attempts to systematically collect and analyze archaeobotanical material, these studies are limited in number. The overwhelming majority (over 80 percent), of archaeobotanical assemblages from South Asian sites represent accidental finds in which less than 10 different species were identified (Weber 1989a). This limited and biased data base is all we have to represent a vast geographical region characterized by a variety of climates, soils and moisture patterns, with a temporal range of nearly six thousand years and that incorporates a variety of sites associated with different cultures at different levels of complexity.

The problem is exacerbated by the fact that much of the plant data is either unpublished, or if published, the methods of collection, the actual proveniences, and bases of the identifications are not available. Nearly all of the paleoethnobotanical studies in South Asia in which large

varieties and numbers of taxa were collected and analyzed in a systematic manner, were part of projects conducted in the eighties.

What becomes apparent is that it is important to examine critically the theories that have been developed which use this information, especially in light of recent studies. The following discussion will therefore include a summary of archaeobotanical finds from South Asian sites, a review of the present perceptions regarding plant use strategies and habitat manipulation based on these finds, and a short review of ideas about the condition of the natural environment in Harappan times, and whether it has changed over time.

Summary of Archaeobotanical Finds

A number of attempts have been made to organize and present summaries of botanical remains from South Asian archaeological sites (e.g. Kajale 1974; Vishnu-Mittre 1974b, Vishnu-Mittre and Savithri 1982; Allchin 1969; Randhawa 1980). These summaries are generally organized by either plant taxa (by species), or by chronological periods (e.g. Neolithic, Harappan, Post-Urban). The problem with such categorizations is that the former stresses biological aspects of plants over their possible cultural significance, and the latter emphasizes phases of evolution, which may or

may not be helpful in explaining the occurrence of particular plant use strategies.

Since Harappan plant use can only be understood in terms of the mosaic appearance of South Asian cultures, and archeaological finds can be best understood as cultural artifacts, the summary presented here will be by site. Each site within the relevant time period (7000-1000 B.C.) will be discussed by region and in terms of the botanical remains recovered during excavation. When available, methods of collection, separation and identification of the remains will be noted, as well as the type of remain (pollen, seed, charcoal), number of specimens recovered and the associated culture and phase. Other than information directly dealing with the archaeobotanical remains, the discussion of each site will be kept to a minimum. In my use of plant taxa names, I have followed the authors of my sources. Omission of certain South Asian sites, or the depth of the discussion relating to certain sites, is due either to their being outside the general region of interest or being occupied at a time that does not coincide with the Early, Mature or Late Phases of the Harappan Civilization.

The following summary is sub-divided by region: I - the Indus system and its western borderlands, II -Gujarat and the western states of India, III - South India, IV -Central India, V-the Ganges Valley. The discussion will focus only on sites in which botanical remains were recovered and those

which were occupied before the Iron Age. At the beginning of the discussion of each region tables will be presented summarizing the important crop plants, the sites they were recovered in, and the time periods they represent. The geographic location of the sites can be found in figure 3 and the alternate common and scientific names of the most common taxa are found in Table 1.

Table 1. Plant names for common recurring crop taxa.

Common/local	Scientific
CEREALS	
Wheat	Triticum aestivum, T. sphaerococcum, T. compactum, T. vulgare
Barley	Hordeum distichum, H. vulgare
Rice	Oryza sativa
Giant millet/jowar	Sorghum bicolor
Finger millet/ragi	Eleusine coracana
Italian (foxtail)	Setaria italica
Kodo(n) millet	Paspalum scrobiculatum
Sawa millet	Echinochloa colonum
Little millet	Panicum miliare
Common (hog) millet	Panicum miliaceum
Pearl millet/bajra	Pennisetum typhoideum
LEGUMES/PULSES	
Lentil	Lens esculenta, L. culinaris
Horse gram	Vigna unguiculata (Vigna sinensis, Dolichos biflorus)
Green gram/mung	Vigna radiata (Vigna radiatus, Phaseolus radiatus)
Black gram	Vigna angularis (Phaseolus mungo)
Grass pea (vetch)	Lathyrus sativus
Field pea	Pisum arvenae
Chick pea	Cicer arietinum
Hyacinth bean	Dolichos lablab
Common pea	Pisum arvense
OILSEED/FIBER	
Linseed	Linum usitatissimum
Mustard	Brassica
Sesame	Sesamum indicum
Cotton	Gossypium
FRUIT	
Melon	Cucumis
Date	Phoenix sylvestris
Jujube/ber	Zizyphus jujube, Z. mauritiana
Grape	Vitis

Figure 3. Map of five sub-regions in South Asia, showing sites with plant material (key on following page).

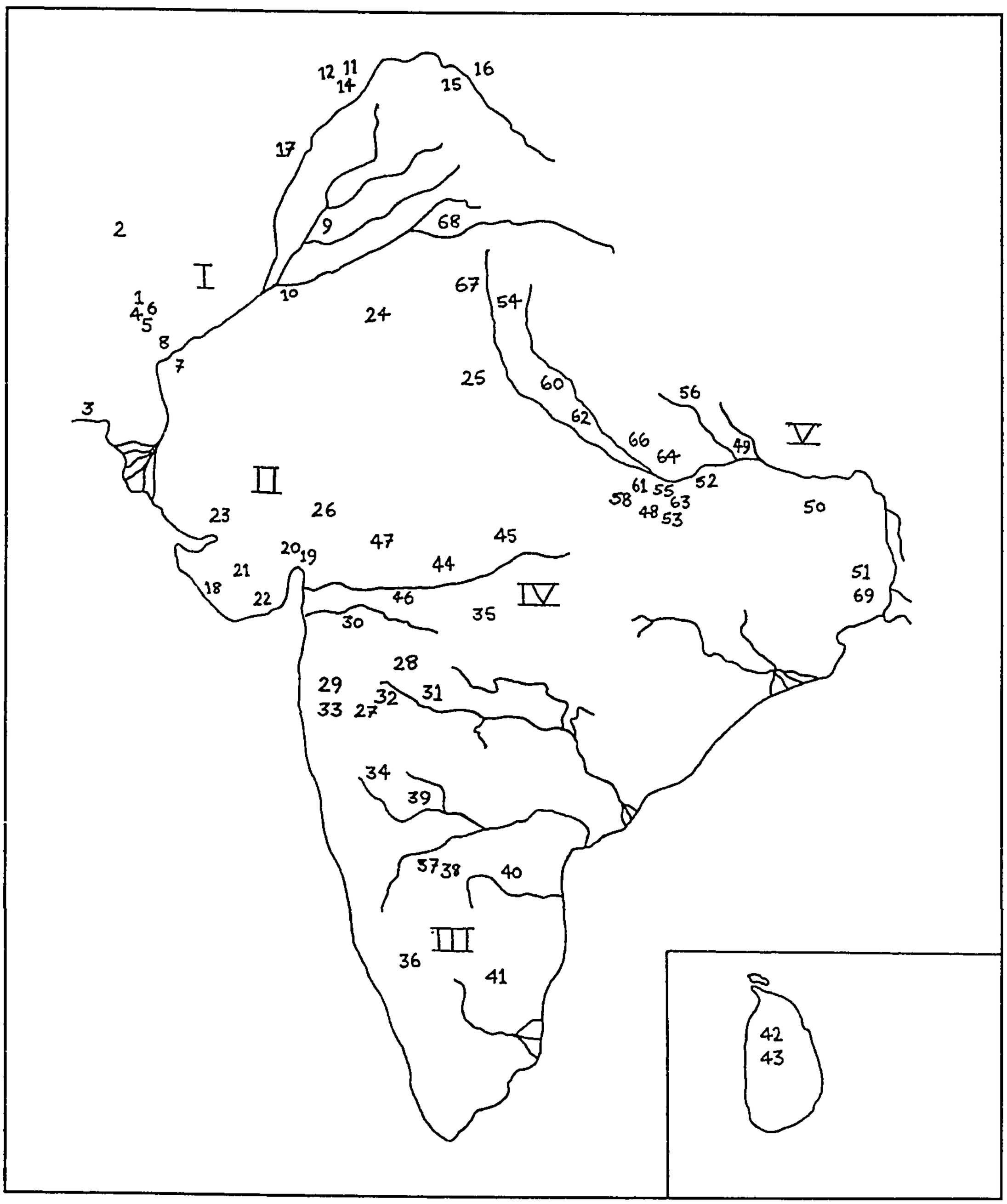


Figure 3 (continued). Numbers correspond to locations on map.

REGION I.

Mehrgarh-1; Mundigak-2; Balakot-3; Nausharo-4; Sibri-5; Pirak-6; Chanhu Daro-7; Mohenjo Daro-8; Harappa-9; Rohira-10; Aligrama-11; Ghalegay-12; Bir-Kot-Ghwandi-13; Loebanr-14; Burzahom-15; Gufkral-16; Tarakai Qila-17.

REGION II.

Prabhas Patan-18; Lothal-19; Rangpur-20; Rojdi-21; Oriyo Timbo-22; Surkotada-23; Kalibangan-24; Noh-25; Ahar-26; Daimabad-27; Kausan-28; Chandoli-29; Prakash-30; Apegaon-31; Nevasa-32; Inamgaon-33; Sonegaon-34; Tuljapur Garhi-35.

REGION III.

Hallur-36; Tekkalkota-37; Sanganakallu-38; Kodekal-39; Ramapurum-40; Paiyampalli-41; Beli-Lena Kitugala-42; Beli Athula-43.

REGION IV.

Kayatha-44; Eran-45; Navdatoli-46; Dangwada-47; Kunjhun-48.

REGION V.

Chirand-49; Oriyup-50; Mashisdal-51; Kakoria-52; Magha-53; Hulas-54; Laharia-Dih-55; Sohagaura-56; Manigera-57; Mahagara-58; Baraunka-59; Atranjikhera-60; Koldihwa-61; Dadupur-62; Chopani-mando-63; Mahadaha-64; Un-65; Sringaverpur-66; Daulatpur-67; Rupar-68; Pandu Rajar Dhibi-69.

REGION I - The Indus System and its Western Borderlands.

The discussion focuses on 17 sites from the Indus River Valley Region, in Baluchistan (Mehrgarh, Mundigak, Balakot, Nausharo, Sibri, and Pirak) and Bannu Basin (Tarakai Qila), Sind (Chanhu-Daro and Mohenjo-Daro), Punjab (Harappan and Rohira), Swat (Aligrama, Ghalegay, Bir-Kot-Ghwandi and Loebanr), Kashmir (Burgahom and Gufkral).

Table 2. Region I (Baluchistan and Bannu Basin) - Main categories of plants by site and time period. ME-Mehrgarh, MU-Mundigak, BA-Balakot, NA-Nausharo, SI-Sibri, PI-Pirak, TQ-Tarakai Qila.

	ME	MU	BA	NA	SI	PI	TQ
CEREALS							
Wheat	EH	EH	-	H	LH	LH	H
Barley	EH	-	EH/H	H	LH	LH	H
Rice	-	-	-	-	-	LH	-
Millets	-	-	-	H	-	LH	-
Other	EH	-	-	H	-	LH	-
LEGUMES							
Peas	-	-	-	-	-	-	H
Lentils	-	-	-	-	-	-	H
Gram	-	-	-	-	-	-	-
Other	-	-	EH/H	-	-	-	-
OILSEED/ FIBER							
Linseed	-	-	-	-	-	LH	-
Mustard	-	-	-	-	-	-	-
Sesame	-	-	-	-	-	-	-
Cotton	EH	-	EH/H	-	-	-	-
Other	-	-	-	-	-	-	-
FRUIT							
Melon	-	-	-	-	-	-	-
Date	EH	-	-	-	-	-	-
Jujube	EH	EH	EH/H	-	LH	LH	-
Grape	EH	-	-	-	-	LH	-
Other	-	-	-	-	-	LH	-
TOTAL TAXA	8	2	46	?	3	14	6

EH-Early Harappan H-Harappan LH-Late Harappan

Table 3. Region I (Sind and Punjab) - Main categories of plants by site and time period.

	SIND		PUNJAB	
	Chanhu-Daro	**Mohenjo-Daro**	**Harappa**	**Rohira**
CEREALS				
Wheat	H	H	H	H
Barley	H	H	H	H
Rice	-	-	-	-
Millets	-	-	-	-
Other	-	-	-	-
LEGUMES				
Peas	H	-	H	-
Lentils	-	-	-	H
Gram	-	-	-	H
Other	-	-	-	-
OILSEED/ FIBER				
Linseed	-	-	-	-
Mustard	H	-	-	-
Sesame	-	-	H	-
Cotton	-	H	-	-
Other	-	-	-	-
FRUIT				
Melon	-	-	H	-
Date	-	-	H	-
Jujube	-	-	-	-
Grape	-	-	-	H
Other	-	-	-	-
TOTAL TAXA	4	3	10	6

EH- Early Harappan H-Harappan LH-Late Harappan
(as per time period, not cultural phase)

Table 4. Region I (Swat and Kashmir) - Main Categories of plants by site and time period. AL-Aligrama, GH-Ghalegay, BKG-Bir-Kot-Ghwandi, LO-Loebanr, BU-Burzahom, GU-Gufkral.

	SWAT				KASHMIR	
	AL	**GH**	**BKG**	**LO**	**BU**	**GU**
CEREALS						
Wheat	-	H/LH	LH	LH	H/LH	H/LH
Barley	LH	LH	LH	LH	LH	H/LH
Rice	LH	-	LH	LH	-	LH
Millets	-	-	-	-	-	LH
Other	-	-	-	-	-	-
LEGUMES						
Peas	-	-	-	LH	LH	H/LH
Lentils	-	-	-	LH	H/LH	H/LH
Gram	-	-	-	-	-	-
Other	-	-	-	-	H/LH	-
OILSEED/ FIBER						
Linseed	-	-	-	LH	-	-
Mustard	-	-	-	-	-	-
Sesame	-	-	-	-	-	-
Cotton	-	-	-	-	-	-
Other	-	-	-	-	-	-
FRUIT						
Melon	-	-	-	-	-	-
Date	-	-	-	-	-	-
Jujube	-	-	-	-	-	-
Grape	-	-	-	LH	LH	-
Other	LH	LH	-	-	H/LH	-
TOTAL TAXA	3	5	3	13	26	14

EH-Early Harappan H-Harappan LH-Late Harappan
(as per time period, not cultural phase)

Mehrgarh. This site contains the earliest evidence in South Asia for domesticated plants in a village setting. Mehrgarh is located at the head of the Kachchi plain at the mouth of the Bolan pass (one of the major entrances to the Indus Plains). The radio-carbon dates from the multiple levels of occupation suggest that the settlement was occupied between the seventh and fourth millennium B.C., and was abandoned before the Mature Indus phase. By the sixth millennium B. C., its inhabitants lived in permanent houses of mud and brick. The subsistence economy was based on domesticated crops (wheat, barley and later cotton) and domesticated animals (sheep, goat and cattle), supplemented by hunting and gathering (Jarrige and Meadow 1980). Evidence for food production at Mehrgarh begins at the earliest aceramic Neolithic levels, where grain impressions revealed cultivated naked six-row barley (displaying many local characteristics), hulled six-row barley or two-row barley, einkorn/emmer wheat, and durum bread wheat (Costantini 1984). While wheat (Triticum) and barley (Hordeum) were the principal crops recovered at Mehrgarh, they were not the only plant material found. Other botanical remains include fruits of the date palm (Phoenix dactylifera), fruit stones of jujube (Zizyphus), oats (Avena), grape (Vitis vinifera), acacia (Acacia) and as cotton (Gossypium) (Costantini 1981:32).

Due to the type of sediment and fragile nature of the botanical remains from Mehrgarh, the sediment was not

floated. The identification was based on carbonized seeds and seed impressions in mud bricks. The importance of the Mehrgarh material is that it is contemporary with early West Asian Neolithic sites, and that some of the cereal grains from the earliest levels are domesticated and represent the earliest evidence yet available for settled agriculture in South Asia. For further information about the site of Mehrgarh see Jarrige (1979, 1984a, 1984b) and Jarrige and Lechevallier (1979).

Nausharo. The Urban Phase site of Nausharo is located near Mehrgarh. A large volume of carbonized botanical material was recovered from the burned remains of one period of occupation. This material, being analyzed by Costantini, is reported to be in press at the time of writing, although the remains include wheat, barley and some millets (Costantini 1987: personal communication). For further information about this site see Jarrige (1986) and Meadow (1988).

Balakot. Located in Baluchistan, along the coastal plain of Las Bela, Balakot was occupied within the fourth and third millennia B.C. (Dales 1974, 1981). Both a Pre-Harappan, or Balakotian Period, and a Mature Urban Harappan Phase are represented at the site. The carbonized seeds and fruits from Balakot were poorly preserved and few in number (West 1976). Six-row barley (*Hordeum vulgare*) was the most common

plant taxon recovered throughout the cultural sequence (McKean 1983:21; Dales 1979:257, 1979; West 1976). Jujube (<u>Zizyphus</u>) was also found in both periods, a few poorly preserved seeds of chickweed (<u>Stellaria</u>) were recovered in the Balakotian Phase and a fragment of <u>Acacia</u> fruit was found in an oven from the Urban Harappan Phase (West 1976; McKean 1983:21). Finally, legumes were also recovered, but they could not be identified to genus or species.

Pollen was also analyzed from Balakot. All pollen taxa identified from the archaeological record were also represented in the modern profiles implying that the environment during the occupation of the site was similar to what is found today along the coastal plain of Las Bela (McKean 1983:299). McKean (1983:299) states that there is no palynological evidence from Balakot for a different amount of rainfall than at present. Of the 53 samples from Balakot that were examined, only 32 samples contained a minimum 200 pollen grains, the desired number for accurate representative counts. Fourty-two different plant taxa are represented in these pollen samples, including cotton (see McKean 1983 for complete list of all 43 recovered families). These taxa are basically identified to family and genera or species, with differing numbers of pollen grains found representing each category. When the pollen data is added to the macro botanical remains, the picture that emerges is of local plant collection, small garden cultivation and field agriculture

dependent on irrigation, and a plant economy which includes pulses, barley and cotton (McKean 1983).

Mundigak. In Southeast Afghanistan, northwest of Mehrgarh, the site of Mundigak rests on the now dry tributary of the Arghandab River. The chronological sequence from this site reinforces the trends observed at Mehrgarh. The initial occupation (Period I) contained no identifiable structures and probably represents a semi-nomadic settlement (Casal 1961; Allchin and Allchin 1982:102). It is in the more permanent settlement of Period II (fourth millennium B.C.), that there is botanical evidence for agriculture. Period II has mud brick houses, large ovens, and even a compartmented stamp seal. Four types of wheat (Triticum aestivum, T. sphaerococcum, T. compactum, and T. vulgare) make up the bulk of the identified remains from this period (Allchin 1969:323-329; Allchin and Allchin 1982:103). Also from Period II were carbonized remains of jujube (Zizyphus). There is no consensus as to whether the jujube is Z. jujube or Z. vulgaris and whether it represents a wild state or a domesticated variety.

Sibri. Located on the northern tip of the Kachi Plain in Baluchistan, near the sites of Mehrgarh, Nausharo, and Pirak, is the site of Sibri, occupied at the beginning of the second millennium B.C. A limited amount of plants were uncovered

and identified. To date, two types of wheat (Triticum aestivum and T. sphaerococcum), three varieties of barley (Hordeum vulgare var. nudum, H. vulgare, and H. sphaerococcum), and possibly jujube (Zizyphus jujube) have been identified (Meadow 1988).

Pirak. This site is located a short distance from Mehrgarh and Naushahro, and is the last site in Baluchistan to be discussed here. Pirak has three periods of occupation spanning the second millennium B.C. (Casal 1973; Jarrige 1985:35-67; Allchin and Allchin 1982:234). The presence of wheat, barley, rice and millets from all periods of occupation indicate the presence of farming practices associated with staple food plants (Costantini 1979:3). The large volume of identified plants which represent cultivation and domestication occurring at Pirak include: Triticum (T. vulgare-compactum, and T. sphaerococcum), Hordeum (H. distichum and H. vulgare), Oryza sativa (rice), Avena (oat), Sorghum (jowar), Panicum (little millet), Linum usitatissimum (linseed), Zizyphus jujuba (jujube), Vitis (grape), Citrullus (colocynth), Cicer arietinum (chick peas) (Costantini 1979b:277).

Chanhu-Daro. This large settlement, located in the Sind region of Pakistan within the Indus plain, is an Urban Phase Harappan site (see: Ehrenfels 1937, 1939; Mackay 1943, 1943;

Allchin and Allchin 1982:241-142). A limited variety of food grains were recovered, including only *Triticum* (wheat), *Hordeum* (barley), *Pisum* (pea), and *Brassica* (mustard) (Shaw 1943:250-251, Vishnu-Mittre and Savithri 1982:207). Of these carbonized grains, wheat (*T. vulgare* and *T. compactum*) was the most common. Several hundred wheat caryopses were also recovered. Interestingly, most of these grains were recovered from storage bins (Shaw 1943). The only other taxa identified from Chanhu-Daro were a few complete grains of barley in association with over 100 barley caryopses. For further description of the botanical finds see Agrawal (1982:93,132) and McKean (1983:68).

Mohenjo-Daro. Located within the Indus flood plain, not far from Chanhu-Daro, Mohenjo-Daro is the only other site from Sind in which archaeobotanical remains were recovered. This very large Harappan city, occupied during the Mature Urban Phase, had an estimated population of over 30,000 people (Marshall 1931, Dales 1965, Allchin and Allchin 1982:175-180). The majority of the cereal grains were wheat (*Triticum spaheracoccum*, *T. compactum*, and *T. vulgare*) (Marshall 1931). A few fragments of barley (*Hordeum vulgare*) and fragments of cotton string and dyed matter were also found at Mohenjo-Daro (Vishnu-Mittre and Savithri 1982:207).

Harappa. This is one of only two Mature Urban Phase sites located in the Punjab in which carbonized botanical remains have been recovered. Harappa, one of the type sites of the civilization, was a large city with a population slightly lower than that of Mohenjo-Daro. For further information on Harappa see Vats (1940), Wheeler (1947), Dales and Kenoyer (1987). Most of the material from Harappa comes from carbonized lumps of seeds and soil. Seeds of wheat (*Triticum compactum* and *T. sphaerococcum*), barley *Hordeum vulgare*, peas (*Pisum arvense*), and sesame (*Sesamum indicum*) were found in this manner (Vats 1940). Other seed remains include those of melon and dates (Vats 1940, Vishnu-Mittre 1974:22). The few pieces of charcoal selected for analysis indicate the presence of jujube (*Zizyphus*), rosewood (*Dalberghia latifolia*), deodar (*Cedrus*) and elm (*Ulmus*) (Chowdhury and Ghosh 1951:17).

In recent excavations (1987-1989), the collection of archaeobotanical material has been resumed. While the floated soil is still being analyzed, threads of cotton have been identified. Further, the examination of seed impressions in some charred and well compacted soil has led to the preliminary identifications of *Phoenix dactylifera* (date), barley and pea (personal observation).

Rohira. From the Urban Harappan occupation of the site of Rohira, located in Punjab, a variety of botanical material

has been identified (Indian Archaeology Review 1982-83:65-66). Dating to around 2100 B.C., Hordeum vulgare (barley), Triticum sphaerococcum (wheat), Dolichos biflorus (horse gram), Lens culinaris (lentil), and Vitis vinifera (grape) have all been identified (Indian Archaeology Review 1984-85).

Loebanr. Occupied during the opening centuries of the second millennium B.C. (1700-1400), the site of Loebanr is located in Swat, within the northern region of Pakistan. From Loebanr III a large number of carbonized seeds and fragments were recovered by flotation (Allchin and Allchin 1982:114-115). These seeds represent both cultivated and wild plants, which implies both gathering and cultivating were practiced. From Loebanr III, three varieties of barley (H. vulgare, H. vulgare var. nudum, and H. distichum) are represented by 143 well-preserved seeds (Costantini 1977:704, 1987:165). Rice was represented by nine carbonized grains, and wheat was limited to 17 seeds. Three probable fragments of rye were also recovered. The second most popular taxon was lentil (Lens culinaris), which was represented by 64 seeds (Costantini 1987:165). Only one seed of Pisum sativum (pea) and two of Vitis vinifera (grape) were recovered (Costantini 1987:165). The only oil seeds observed were 11 grains of Linum usitatissimum (linseed).

Four different taxa representing weeds were also recovered. These include the four seeds of Aegilops, two

seeds of *Argemone*, three grains of *Galium*, and one seed of *Secale* (Costantini 1987:155-165). Finally, a number of unburned taxa occur which are probable modern contaminants (*Brassica*, *Euphorbia*, *Lithospermum*, *Medicago*, *Raphanus*, *Sinapis*, *Cucumis*, and *Vitis*).

The existence of wheat, barley, rice, lentil, pea and grape suggests a diverse diet involving irrigation and the use of different crops during different seasons of the year, as well as the use of wild plants in association with domesticated crops.

Aligrama. Also located in the Swat Valley, a little more than four kilometers from Loebanr, is the settlement of Aligrama. This site was occupied about the same time as Loebanr (1700-1400 B.C.), during the beginning of the second millennium B.C. (Allchin and Allchin 1982:115-116). Soil was floated from various levels of the site revealing a variety of carbonized seed remains. Seeds and fragments of barley, rice, hackberry and a variety of leguminous remains were all recovered. The similar types of remains and close proximity in time and space to Loebanr suggest a similar form of subsistence and farming practice involving irrigated agriculture with different plants at different seasons.

Ghalegay. This rock shelter has been almost continuously occupied since the beginning of the third millennium B.C.

(Costantini 1987:155). Archaeobotanical remains were recovered from a number of different periods of occupation. From a hearth in Period III (1900-1700 B.C.) a single barley seed was recovered, though fragments of barley straw were observed in abundance (Costantini 1987:155-156). Sixteen charred grains of wheat (Triticum sphaerococcum), one spurge seed (Euphorbia helioscopia) and an achene of gromwell (Lithospermum arvense) were recovered from period III (2400-1900 B.C.). Finally, fruit stones belonging to hackberry (Celtis australis) were recovered from both Periods I (3000-2500 B.C.) and Period II.

Bir-Kot-Ghwandi. Soil samples were collected from this site, located in Swat, which was occupied between 1700-1400 B.C. Three different types of cereal grain are represented in the soil from the occupation layers of a dwelling. In all, 88 charred seeds were recovered, of which 12 were wheat (Triticum aestivum), 39 were rice (Oryza sativa) and 37 were barley (Hordeum vulgare) (Costantini 1987:165).

Burzahom. This site is situated in the Kashmir Valley, in northwest India. Four periods of occupation have been identified, labelled Burzahom Neolithic I (2375-1700 B.C.), Burzuhom Neolithic II (1700-1000 B.C.), Megalithic Period (1000-600 B.C.), and Early Historic (600 B.C.-200 A.D.) (Khan 1987, Indian Archaeology, A Review 1960-61:11, 1961-62:17-

21, 1962-63:9-10, 1964-65:13, 1966-67:16-17, 1971-72:24, 1973-74:15). The ceramic material from Burzahom is distinctly of a non-Indus and non-Baluchistan tradition (Allchin and Allchin 1982:111-112), implying the existence of a local style. Soil samples from various levels of all four periods of occupation were examined for plant remains. With the use of hand sorting, dry screening, and water flotation, a large collection of seeds and charcoals were collected for analysis. With the use of a comparative collection accurate identification of these remains was possible. The complete description, analysis and interpretation of these remains was performed and written by Khan (1987).

Wheat (Triticum aestivum and T. sphaerococcum) and barley (Hordeum vulgare) were found in all four periods. Rice was recovered only in the latter two periods. Of the pulses, lentils (Lens culinaris) were found in all periods of occupation while pea (Pisum sativum) occurred in just Period III and IV. While some species of Prunus (cherry/plum), Juglans (walnut),and Galium (bedstraw) were recovered in each period, Celtis (hackberry) and Lithospermum (gromwell) were collected from samples representing period II, III and IV. Other plants represented in the Burgahom record include Vicia (vetch) and Astragalus (milkvetch) (Periods I, III, IV); Medicago (medick) (Period I, IV); Spomoea (Periods I, II, IV); Populus (poplar) (Periods I, II,

III); Quercus (oak) (Periods I, II); Pinus wallichinana (pine) (Periods I, III); Fraxinus excelsior (ash) (Periods I, II); Ulmus (elm), Ficus sp. (fig) and Crataegus osyacantha (hawthorn) (Period I); Vitis vinifera (grape) and Picea (spruce) (Period II); Platanus orientalis (sycamore); Cedrus deodara (Period IV); and, Melilotus albus (clover) (Period II and III) (Khan 1987:190-191).

The consistent appearance of wheat, barley, lentil, pea and certain wild plants throughout the occupation, suggest a stable diet involving irrigation agriculture. The introduction of plants such as grape and almonds in Period II, and rice in Period III, show that dietary changes were also occurring throughout the site's occupation.

Gufkral. Located in the Kashmir Valley, just 47 km from Burgahom, is the Neolithic site of Gufkral. Three cultural periods have been identified, which are labelled Neolithic (containing three subphases: Aceramic (IA), Early (IB) and Late (IC), Megalithic and Historic (Sharma 1982, Indian Archaeology, A Review 1981-82:19-25). Not only are the sites of Burgahom and Gufkral similar in terms of location and periods of occupation, but the botanical records are also similar in many respects. In fact, all plant species found at Gufkral occurred at Burgahom. A diverse collection of carbonized seeds were recovered from soil flotation. From Period I, barley, wheat, lentil and a common weed

(Lithospermum arvenae) were found (Sharma 1981:24). Pea was recovered in only sub level IB and IC. All grains found in Period I were recovered in Period II and III with the addition of rice and ragi (Eleusine coracana) (Sharma 1981:24).

Recent analysis of the charcoal from this site has increased our knowledge of plant occurrences at Gufkral. Chanchala (1984:115-118) has identified Pinus wallichiana (pine), Picea smithiana (spruce), Juglans regia (walnut), Aesculus indica, Ulmus wallichiana (elm), Prunus (cherry/plum), and Buxus wallichiana. For further information about the plant remains from the site of Gufkral see Kajale (1981), Chanchala (1984), Sharma (1981), and Kahn (1987).

Tarakai Qila. Tarakai Qila is a well stratified site in the Bannu Province, in the north west frontier region of Pakistan (Allchin and Allchin 1982:152,154). Dating to the third millennium B.C., a huge number of charred seeds and a few fragments of silica skeletons of stalks and glumes have been recovered. The charred remains have been identified as wheat, barley, lentil and pea (Thomas 1979:231).

REGION II - Gujarat and the Western States of India

The discussion includes sites in two sub-regions of Gujarat, Saurashtra (Lothal, Rangpur, Oriyo Timbo, Prabhas

Patan, and Rojdi) and Kutch (Surkotada), in Rajasthan (Kalibangan, Noh, and Ahar), and in Maharashtra (Daimabad, Kausan, Chandoli, Prakash, Apegaon, Nevasa, Inamgaon, Sonegaon, and Tuljapur Garhi) (figure 3 and tables 5, 6, 7).

Table 5. Region II (Gujarat and Rajasthan) - Main categories of plants by site and time period. PP-Prabhas Patan, LO-Lothal, RA-Rangpur, RO-Rojdi, OT-Oriyo Timbo, SU-Surkotada, KA-Kalibangan, NO-Noh, AH-Ahar.

	SAURASHTRA					KUTCH		RAJASTHAN	
	PP	**LO**	**RA**	**RO**	**OT**	**SU**	**KA**	**NO**	**AH**
CEREALS									
Wheat	-	-	-	-	-	-	EH/H	-	-
Barley	-	-	-	H	-	-	EH/H	-	H/LH
Rice	-	H	-	-	-	-	-	LH	H
Millets	-	-	H	H/LH	LH	H	-	-	H
Other	-	-	-	H	LH	-	-	-	-
LEGUMES									
Peas	H	-	-	LH	-	-	H	-	H/LH
Lentils	-	-	H	LH	-	-	H	-	H/LH
Gram	H	-	-	H/LH	LH	-	-	LH	H
Other	-	-	-	H/LH	-	H	H	-	H
OILSEED/ FIBER									
Linseed	-	-	-	-	-	-	-	-	-
Mustard	-	-	-	H/LH	-	-	-	-	-
Sesame	-	-	-	-	-	-	-	-	-
Cotton	-	-	-	-	-	-	-	-	-
Other	-	-	-	H/LH	-	-	-	-	-
FRUIT									
Melon	-	-	-	-	-	-	-	-	-
Date	-	-	-	-	-	-	-	-	-
Jujube	-	-	-	H/LH	-	-	-	-	-
Grape	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	H	-	-	-
TOTAL TAXA	3	5	14	80	12	24	23	3	8

EH-Early Harappan H-Harappan LH-Late Harappan
(as per time period, not cultural phase)

Table 6. Region II (Maharashtra) - Main categories of plants by site and time period. DA-Daimabad, KA-Kauson, CH-Chandoli, PR-Prakash, AP-Apegaon, NE-Nevasa, IN-Inamgaon, SO-Sonegaon, TG-Tuljapur Garhi.

	DA	KA	CH	PR	AP	NE	IN	SO	TG
CEREALS									
Wheat	LH	-	-	-	-	-	LH	LH	LH
Barley	LH	-	-	-	-	-	LH	-	LH
Rice	-	-	-	-	-	-	LH	-	LH
Millets	LH	LH	-	-	-	LH	LH	-	LH
Other	-	-	-	-	-	-	LH	-	-
LEGUMES									
Peas	LH	-	-	-	LH	LH	LH	-	LH
Lentils	LH	-	-	-	-	-	LH	-	LH
Gram	LH	-	-	-	LH	LH	LH	-	LH
Other	LH	-	-	-	-	LH	LH	-	-
OILSEED/ FIBER									
Linseed	-	-	LH	-	-	-	-	-	-
Mustard	-	-	-	-	-	-	-	-	LH
Sesame	-	-	-	-	-	-	-	-	-
Cotton	-	-	LH	-	-	LH	-	-	-
Other	-	-	-	-	-	-	LH	-	-
FRUIT									
Melon	-	-	-	-	-	-	-	-	-
Date	-	-	-	-	-	-	LH	-	-
Jujube	LH	-	-	-	LH	LH	LH	-	-
Grape	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	LH	-	LH
TOTAL TAXA	37	1	2	7	4	8	34	3	17

EH-Early Harappan H-Harappan LH-Late Harappan
(as per time period, not cultural phase)

Lothal. Few cereal grains were recovered from this Mature Urban Harappan site. Located in Saurashtra, the only identifiable plant remains recovered from Lothal 'A' were rice imprints of husks and spikelets (Vishnu-Mittre 1974:13, Vishnu-Mittre and Savithri 1982:207). Vishnu-Mittre and Savithri (1982: 207) argue that these imprints represent remains of wild rice. From Lothal 'B' both Sesamum and Setaria (Italian millet) are reported to have been found, though their identification is questionable. Charcoal representing 3 different taxa were also identified at Lothal, Adina cordifolia (haldu), Albizzia (siris) and Soymida febriluge (Indian Redwood) (Chanchala 1984:157-170). For further information about this site refer to Rao (1962, 1973, 1979), Allchin and Allchin (1982:169-175), and Indian Archaeology, A Review (1955-56:6-7, 1956-57:15-16, 1958-59:13-15, 1959-60:16-18, 1961-62:9-10).

Rangpur. This site, also located in Saurashtra, shows more of a mix of traits than does Lothal. Occupied during both Urban and Post-Urban Phases, a variety of plant remains have been recovered from Rangpur. Information on Rangpur can be obtained from such sources as Rao (1963), Leshnik (1968), and Sankalia 1974:379-380)

Thirty-six samples of charcoal or charred lumps of mud-plaster were analyzed, some representing each period of occupation. In period IIA, two pieces of charcoal were

identified as Acacia and Melia (mahogany) and a rice husk impression was observed embedded in mud plaster (Ghosh and Lal 1962:171-172). Charcoal of Acacia (eight samples) and one sample of Tamarix (salt-cedar) were recovered from Period IIB. From Period IIC, Acacia (three samples or pieces) and Albizzia (three samples) charcoal were identified. And from Period III, charcoals representing Acacia (five samples), Albizzia (four samples), Soymida fibrifuga (two samples) and Pterocarpus santalinus (one sample) were observed as well as seeds of Pennisetum typhoides (pearl millet) (Ghosh and Lal 1963:171). The grains of pearl millet were found lumped in a tar-like matrix. Charcoals representing Tectona and Adena (haldu) are also reported to be represented in the Rangpur record (Randhawa 1980:180), as well as Melia azedarch (Chanchala 1984:158). Sankalia (1974) also identified the presence of lentil dating between 2000 and 800 B.C.

Prabhas Patan. Located in Gujarat, the site of Prabhas Patan (Somnath) is considered an Urban Phase site (Indian Archaeology, A Review 1971-72, 1975-76, 1976-77; Sankalia 1972; Nanavati et al. 1971). Dating to between 2300 and 1700 B.C., three different taxa have been identified (Possehl and Rissman 1987:82-83). Large quantities of gram with smaller amounts of pea have been found at Prabhas Patan (Sankalia 1974).

Rojdi. This Saurashtran site will be discussed in detail the following chapters, and will therefore not be discussed here.

Oriyo Timbo. The final site in Saurashtra where botanical remains have been identified is the late Post-Urban Phase site of Oriyo Timbo. Due to the success of soil flotation, a variety of seeds were recovered. These seeds have been identified as belonging to the following taxonomic categories: Setaria (S. italica, S. viridis and S. glauca), Eleusine (possibly E. coracana), Panicum (probably P. miliare), Solanum (nightshade), Molluga (Indian chickweed), Chenopodium, Euphorbia (spurge), Trianthema (gadabani) and a variety of Leguminous types (Wagner 1983a, 1983b; and personal observation). Hundreds of carbonized and uncarbonized seeds were found representing both wild and domesticated species. The site of Oriyo Timbo is believed to be a seasonal herding camp (Rissman 1985).

Surkotada. Located in Kutch, the settlement of Surkotada was occupied during the Urban Phase (Joshi 1972a, 1972b, 1979). The source of the botanical remains was several charred lumps of seeds. These lumps contained a variety of species and some contained nearly 600 seeds (Vishnu-Mittre and Savithri 1982:214). While many of the identifications have been described as tentative, the following are thought

to be represented in these lumps: Setaria (foxtail millet), Eleusine coracana (finger millet), Phragmites karka (reed), Andropogon (bluestem), Brachiaria, Panicum (little, hog or common millet), Echinochloa (sawa millet), Eragrostis (lovegrass), Digitaria (crabgrass), Scirpus (bulrush), Carex (sedge), Eriogonum (wild-buckwheat), Cheno-Ams (goosefoot and pigweed), Trifolium repens (white clover), Stellaria (chickweed), Euphorbia pyomostegia (spurge), Poa (bluegrass), Polygonum (smartweed) and Trianthema (gadabani) (Joshi 1972a; Vishnu-Mittre 1974; Vishnu-Mittre and Savithri 1982:214).

The actual location of this material is not stated in the literature although the three lumps of charred material are associated with Period IC of the occupation. While there is no indication of how representative this material is of the dietary practices of the the occupants of Surkotada, it does show for the first time the importance of wild plants in South Asian settlements.

Noh. The site of Noh is located in Rajasthan and is considered a Chalcolithic site (Indian Archaeology, A Review 1963-64:28-29, 1964-65:34-35, 1966-67:30-31, 1970-71:31-32, 1971-72:41-42). From the Pre Painted Grey Ware and B and R ceramics levels of the site, seeds of horse gram, mug and rice impressions in burnt clay were recovered (Savithri 1976:160). From the Mauryan levels, seeds of rice and green

gram were observed and from Kushan levels, barley was identified.

Kalibangan. On the bank of the now dry river of Ghaggar, in what is today northern Rajasthan, India, is the site of Kalibangan. The settlement consists of both pre-Urban and Urban Phases (for a description of the site see: Thapar 1969, 1973, 1975; Lal 1979, 1981; Indian Archaeology, A Review 1961-62:39-44, 1962-63:20-31, 1963-64:30-39, 1964-65:35-39). The botanical remains recovered from Kalibangan are in the form of charred wood, carbonized seeds and seed impressions. No flotation or screening was performed. The majority of the recovered grains were barley (Hordeum vulgare). Many of these grains were unusually small (much like the Rojdi material in size) and twisted, suggesting they belonged to six rowed barley (Vishnu-Mittre 1974:18). Both naked and hulled varieties were recovered, although the hulled variety outnumbered the naked type by a ratio of around 100 to one (Savithri 1976:146). Grains of barley are represented in both phases of occupation. Five grains of carbonized wheat (Triticum sphaerococcum) have reportedly been identified from Kalibangan (Vishnu-Mittre 1974:8-9) but disagreement exists as to whether these grains represent aberrant forms of wheat, or some other cereal grain (Savithri 1976:152). Three carbonized seeds of chickpea (Cicer arietinum) and one seed which resembles field pea (Pisum arvense) were also recovered

from the Urban Harappan Phase at Kalibangan (Vishnu-Mittre and Savithri 1982:213). Along the inner surface of a pot sherd from the Pre-Urban Phase were transparent clayey crystals belonging to selenite gypsum (Vishnu-Mittre and Savithri 1982:214). Finally, the analysis of charcoals has led to the identification of Acacia, Dalbergia (heartwood), Anogeissus (axlewood), and Tectona (teak) from the Pre-Harappan Phase, and Acacia, Anogeinssus, Albizzia (siris), Dalbergia, Terminalia (laurel, arjun, belliric or chebulic myrobalan, or silvergrey wood), Tamarix diaca (salt-cedar), Morus alba (mulberry), Tectona grandis, Boswellia serrata (Indian Olibanum Tree), Salvadora persica (saltbush), Calligonum (phog), and Ficus (fig) from the Urban Phase (Savithri 1976:145). From the Pre-Urban Phase, charcoal of Acacia, Tectona grandis, and Dalbergia have all been identified.

Ahar. The site of Ahar is located in southwestern Rajasthan and was occupied from the middle of the third millennium to the middle of the second millennium (Possehl and Rissman In Press:69; Sankalia et al. 1969). Few plant remains were recovered from any of the three periods of occupation (IA 2600-2150 B.C., IB 2150-1950 B.C., IC 1950-1500 B.C.). Impressions of seeds and charcoal were the only botanical remains identified from this site. Impressions of rice and two millets (Sorghum and Pennisetum) have been identified

(Vishnu-Mittre 1974). Savithri (1976:59) reports that rice appears in the earlier levels then disappears in the later periods when the millets first appear. The only charcoal identified at the site belongs to Soymida fabrifuga (Indian redwood) (Savithri 1976:59). There is also reference to barley, rice, lentil, green gram, green pea (Lythyrus sativus), Hyacinth bean (Dolichos lablab), and most samples were collected from ash pits or fire pits (Sali 1982, 1986).

Daimabad. From this site located in Central Maharashtra, five different periods of occupation have been identified. These include the Sarvalda Occupation (Period I 2000-1900 B.C.), Late Harappan (Period II 1900-1800 B.C.), Buff and Cream Ware Occupation (Period III 1800-1700 B.C.), Malwa complex (Period IV 1700-1500 B.C.) and the Jorwe Complex (Period V 1500-1100 B.C.) (Indian Archaeology, A Review 1958-59:15-18, 1974-75:29-31, 1975-76:31-34, 1976-77:33-38, 1978-79:46-52; Sali 1986, 1982:177; Possehl and Rissman In Press:74). From this site, often referred to as Chalcolithic, a variety of botanical remains were identified from sources such as leaf impressions, carbonized seeds and fruits and charcoals. Flotation was carried out at Daimabad. It is not clear from the excavation reports (Sali 1982, 1986), and studies summarizing the analysis of the botanical remains from Daimabad (Kajale 1977; Vishnu-Mittre and Savithri 1982; Sharma 1983; and Chanchala 1984), which

botanical remains come from which period of occupation. The following summary of the archaeobotanical remains from Daimabad will attempt to present as cohrent or accurate a picture as possible using information from all sources just listed.

From Period I, burnt clay lumps containing leaf impressions of grasses were observed (Kajale 1974; Sharma 1983; Chanchala 1984:122). There is also reference to wheat, barley, jowar, and lentils from Period I (Kajale 1977; Vishnu-Mittre and Savithri 1982:215). The only charcoal identification in Period I was *Acacia*, and for Period II was *Boswellia serrota* (Indian olibanum tree).

For Period III, a greater variety of botanical remains have been identified. Seed identifications include field pea, barley, lentil, mug and jujube. Charcoal identifications include *Acacia* and *Anogeissus latifolia* (axlewood).

Most of the identifiable remains are from Period IV and V, which are similar in many ways. Seeds of grass pea, horse gram, Cheno-Ams (goosefoot and pigweed), jujube, three types of wheat (*Triticum aestivus*, *T. compactum*, and *T. sphaeroccum*), finger millet, lentil, were all recovered from these levels as was charcoal of *Acacia*. Found in Period IV and not in V are seeds of *Pavonia odorata* (sugandha-bala) and *Vigna mungo* (black gram) and charcoal of *Anogeissus latifolia*, *Cassia fistula* and *Dalbergia latifolia*. Finally

seeds of Paspalum scrobiculatum (kodo millet), pea, Rhynchosia (rosary-bean) and foxtail millet, and charcoals of jujube and Pterocarpus marsupium (biyo) were recovered from Period V, the Jorwe Complex. The picture from Daimabad is one in which different periods of occupation show some difference in plant usage. This is more obvious in the charcoals than in the seeds.

Inamgaon. Located in Maharashtra, Inamgaon is considered a Chalcolithic site. Its occupation has been identified as belonging to the Malwa and Jorwe cultural complexes and dates between 1600 and 700 B.C. (Indian Archaeology, A Review 1968-69:18-20, 1969-70:25-27, 1974-75:32-36, 1980-81:41-42; Vishnu-Mittre and Savithri 1975a; Vishnu-Mittre and Gupta 1976) Flotation yielded most of the carbonized material from the site (Kajale 1988:728-819). The following taxa have been identified: rice, wheat (Triticum sphaerococcum, T. aestivum), barley, finger millet, Job's tears (Coix lachryma jobi), lentils, chickpea, grass pea, common pea, black gram, green gram, horse gram, hyacinth bean (Dolichos lablab), Indian gamba (Eugenia jambalana or Syaigium cumin), jujube, wild date (Phoenix sylvestris), beleric myrabolam (Terminalia belerica), Phyllanthes emblica (Emblis myrabolan), Buchnania (Cuddapah almond), Pongamia pinnata (Karangja), Abutilon indica (Indian mallow), Cordia myxa (Indian cherry), Cyperus rotundus (common sedge), Setaria italica (Italian millet),

Panicum, Portulaca oleracea (Pearslana), Chenopodium album (Goosefoot), Solanum, Acacia arabica, Acacia nilotica, Cucumis melo (melon), Diospyra melanoxylon (Tendu), Sorghum, Testona grandis, and Albizzia (Kajale 1988b:730-820).

The site of Inamgaon, with its extensive seed record, shows the significance of both wild and cultivated plants in the Chalcolithic. The distribution of grains in various trenches and layers at Inamgaon suggest that the plant economy of the Early Jorwe period was richer than those of the Malwa and Late Jorwe Periods (Kajale 1988:780-800). The most common cereal grains were barley, wild wheat, rice, while millets were recovered in far fewer numbers. From the Malwa to Early Jorwe there was an increase in the intensity and variety of plant cultivation, yet the Late Jorwe occupation shows a sharp decline in the intensity of cultivation (Kajale 1988:780-810). This indicates a development, followed by decline in the agricultural system at Inamgaon. For a complete description and interpretation of the thousands of seeds recovered from Inamgaon see Kajale (1988).

Sonegaon. Another Malwa-Jorwe settlement located in Maharashtra is Sonegaon (Deo 1969; Indian Archaeology, A Review 1964-65:26-28). The botanical material identified from this Chalcolithic site consists mainly of charcoal remains representing Tectona grandis (teak) and Acacia

(Chanchala 1984:131). All charcoals identified from Sonegaon came from the Jorwe occupation. Seeds of wheat have been identified, dating to about 1290 B.C. (Sankalia 1974).

Kausan. The site of Kausan is located in Maharashtra. Chalcolithic (Jorwe) and Early Historic (Satavahan) occupations are present at this site (Indian Archaeology, A Review 1965-66:13, 1984-85). Impressions of Sorghum (jowar) in mud brick have been identified from both these periods of occupation. No other archaeobotanical remains have been recovered.

Chandoli. The Chalcolithic site of Chandoli is located in Maharashtra (see: Indian Archaeology, A Review 1960-61:26-27). Both Jorwe and Malwa ware ceramics are found at this site. Threads recovered from the hole in copper beads have been identified as cotton and linseed/flax (Kajale 1974:69).

Prakash. This site is located on the Deccan Plateau in Maharashtra (Indian Archaeology, A Review 1954-55:13). Seven different plant taxa are represented in the charcoal collected from the Chalcolithic occupation of this site. The identified remains include Albizzia (siris), Anogeissus (axlewood), Dalbergia latifolia (heartwood), Dendrocalamus (bamboo), Holarrhena antilysenterica (kutaja), Tectona

grandis (teak) and Terminalia (myrobalan) (Chanchala 1984:157-170).

Apegaon. The Chalcolithic site of Apegaon is located in Maharashtra (Deo, Dhavalikar and Ansari 1979; Sali 1970; Indian Archaeology, A Review 1976-77:39). Four different species have been recovered: Jujube, pea, common bean, and horse gram) (Chanchala 1984).

Tuljapur Garhi. The Chalcolithic site of Tuljapur Garhi, located in Maharashtra, dates to the first millennium B.C. (see: Indian Archaeology, A Review 1984-85:48-50). In all, 17 different plant species have been identified including cultivated cereals, domesticated pulses, oil and fiber yielding plants, and species commonly used for fodder. They include rice, jowar, wheat, barley, black gram, green gram, common bean, horse gram, lentil, grass pea, chick peas, pigeon pea, Indian gum arabic (Acacia nilotica), mustard, and three unknown or questionable identifications (Kajale 1988:2).

Nevasa. A few botanical identifications have been made at this site, located in Maharashtra. Information on Nevasa can be in Indian Archaeology, A review 1954:5-9, 1955-56:8-11, 1959-60:25-28, 1960-61:19-21. The plants represented at this site include kodo millet, pea, and green gram during the

early periods of occupation, and rice, lentils, and finger millet during later Sutvahana times (150 B.C.) (Savithri 1976:160-161). Cotton has been also identified from about 1500 B.C. at Nevasa (Vishnu-Mittre 1974), as well as grass pea, black gram and jujube (Sharma 1983:115-116).

REGION III - South India and Sri Lanka

The eight sites discussed here are located in Karnatak (Hallur, Tekkalkota, Sanganakallu, Kodekal); Andhra Pradesh (Ramapurum); Tamil Nadu (Paiyampalli) and Sri Lanka (Beli Lena Kitugala and Beli Athula) (figure 3 and table 7).

Table 7. Region III - Main categories of plants by site and time period. The two sites from Sri Lanka are not listed, since only one taxa from either has been identified. HA-Hallur, TE-Tekkalkota, SA-Sanganakullu, KO-Kodekal, RA-Ramapurum, PA-Paiyampalli.

	KARNATAKA				ANDHRA PRADESH	TAMIL NADU
	HA	**TE**	**SA**	**KO**	**RA**	**TA**
CEREALS						
Wheat	-	-	-	-	-	-
Barley	-	-	-	-	-	-
Rice	LH	-	-	-	-	LH
Millets	LH	LH	-	-	-	LH
Other	-	-	-	-	-	-
LEGUMES						
Peas	-	-	-	-	-	-
Lentils	-	-	-	-	-	-
Gram	LH	LH	-	-	-	LH
Other	-	LH	-	-	-	-
OILSEED/ FIBER						
Linseed	-	-	-	-	-	-
Mustard	-	-	-	-	-	-
Sesame	-	-	-	-	-	-
Cotton	-	-	-	-	-	-
Other	-	-	-	-	-	-
FRUIT						
Melon	-	-	-	-	-	-
Date	-	-	-	-	-	-
Jujube	-	-	-	-	-	-
Grape	-	-	-	-	-	-
Other	LH	LH	-	H	-	-
TOTAL TAXA	9	6	4	1	2	4

EH-Early Harappan H-Harappan LH-Late Harappan
(as per time period, not cultural phase)

Hallur. The Neolithic site of Hallur, located in Karnataka, was occupied between 2100 and 1100 B.C. (Indian Archaeology, A Review 1964-65:31-32, 1976-77:25). Botanical remains were recovered from both the Neolithic and Iron Age Periods in the form of carbonized seeds and charcoal (Vishnu-Mittre 1971b; Savithri 1976:142). The Neolithic seeds have been identified as finger millet (either Eleusine coracana or E. indica) and kodo millet (Vishnu-Mittre 1971:127). Fruits of Tectona grandis have been identified that belong to the Neolithic occupation. On rusted iron implements were found encrustations of spikelets of rice and are from the late occupation of Hallur (Vishnu-Mittre 1971:128). Charcoal from the Neolithic occupation represent Holarrhena antidysenterica (kutaja), Polyalthia (mast tree), Albizzia (siris), and Anogeissus (axlewood) (Savithri 1976:142). Horse gram has been associated with Hallur II (Allchin and Allchin 1982:292).

Tekkalakota. This South Indian Neolithic site was contemporary with Hallur. A few botanical remains have been collected and identified from this site representing both the Neolithic and Iron Age Periods of occupation (Indian Archaeology, A Review 1963-64:24-25). The analyzed charcoal remains have all been identified as Soymida febrifuga (Indian Redwood) (Savithri 1976:142). Carbonized seeds of horse gram, grass pea, black gram, and jujube are also present

(Vishnu-Mittre 1974, 1977, 1979a; Savithri 1976:142-144). Finger millet has been identified in association with Tekkalakota I (Allchin and Allchin 1982:292).

Kodekal. Located in Karnataka, the site of Kodakal dates to about 2300 B.C. (Sankalia 1974). From this Neolithic site, fruits of jujube were recovered (Chanchala 1984 and Sankalia 1974).

Sanganakallu. The final Neolithic site from Karnataka, in which archaeobotanical remains were recovered, is Sanganakallu (Indian Archaeology, A Review 1964-65:29-30). Dating to about 1500 B.C., charcoal representing three different species has been identified. These are Acacia, Albizzia, and Soymida febrifuga (Savithri 1976: 144). No other botanical remains have been identified from this site.

Ramapuram. Only two species have so far been identified from this Chalcolithic site (Indian Archaeology, A Review 1980-81:3-7, 1981-82:3-8, 1982-83:3-6, 1983-84:3-5). Wood belonging to Hardwickia binata (anjan or yepi tree) and Gmelina arborea (gambhar tree) were both identified. Both these species can be found growing in the region of the site today, or throughout much of Andhra Pradesh.

Paiyampalli. This Neolithic-Megalithic site is located in Tamil Nadu (Indian Archaeology, A Review 1964-65:22-23, 1967-68:26-30). A limited number of carbonized grains were recovered from Paiyampalli. Dating to about 1400 B.C., green gram, horse gram, rice, and finger millet have all been identified (Allchin and Allchin 1982:292; Sankalia 1974).

Beli-Lena Kitugala. This Sri Lankan site dates to the microlithic at about 10,000 B.C. The only archaeobotanical remains identified from this site have been described by Kajale as granules from the charred epicarp of the edible wild breadfruit of Artocarpus nobilis (Possehl and Rissman In Press:25).

Beli-Athula. The archaeobotanical remains from this site, which is located in Sri Lanka, are thought to date to the microlithic (Possehl and Rissman In Press:25). These remains still have not been identified to species.

REGION IV - Central India

Central India has five archaeological sites from which botanical remains have been recovered and identified. All of these sites (Kayatha, Eran, Navdatoli, Dangwada, and Kunjhun) are located in Madhya Pradesh (figure 3 and table 8).

Table 8. Region IV - Main categories of plants by site and time period.

	Kayatha	Eran	Navdatoli	Dangwada	Kunjhun
CEREALS					
Wheat	LH	-	LH	LH	-
Barley	-	-	LH	-	-
Rice	-	-	LH	-	-
Millets	-	-	-	-	-
Other	-	-	-	-	-
LEGUMES					
Peas	-	-	LH	-	-
Lentils	-	-	-	LH	-
Gram	LH	-	LH	LH	-
Other	-	-	LH	LH	-
OILSEED/ FIBER					
Linseed	-	-	-	-	-
Mustard	-	-	-	-	-
Sesame	-	-	-	-	-
Cotton	-	-	-	-	-
Other	-	-	-	-	-
FRUIT					
Melon	-	-	-	-	-
Date	-	-	-	-	-
Jujube	LH	-	-	LH	-
Grape	-	-	-	-	-
Other	LH	-	-	-	-
TOTAL TAXA	5	1	15	10	1

EH-Early Harappan H-Harappan LH-Late Harappan
(as per time period, not cultural phase)

Kayatha. Kayatha represents a number of different periods of occupation (Indian Archaeology, A Review 1964-65:18-19, 1967-68:24-25). Three periods are of interest here: the Kayatha Period (2450-2000 B.C.), the Banas Period (1950-1700 B.C.), and the Malwa Period (1700-1400 B.C.) (Possehl and Rissman In Press:71). Charcoal representing _Acacia_ was recovered in the Kayatha and Banas Periods while charcoal representing _Cassia fistula_ was found only in the Banas Period (Chanchala 1984:133-134). Seeds of wheat, jujube and horse gram were recovered from the Malwa Period (Vishnu-Mittre 1984). No botanical remains have yet been associated with the Kayatha Period.

Eran. The site of Eran, located in Madhya Pradesh, is considered a Malwa site, occupied between 1700-1400 B.C. (Possehl and Rissman In Press:89; Pandey 1982; Singh 1962; Indian Archaeology, A Review 1960:17-18, 1961-62:24-25, 1962-63:11-12, 1963-64:15-16, 1964-65:16-18). Charcoal identified as _Soymida febrifuga_ (Indian Redwood) was the only botanical remain recovered and analyzed (Savithri 1976:154-160).

Navdatoli. One of the best known Malwa Complex sites, Navdatoli, is located in Madhya Pradesh (Indian Archaeology, A Review 1957-58:29,30-33,35, 1958-59:30-31, 1970-71:20-22; Sanlalia et al. 1971). The four periods of occupation are dated to 2000-1600 B.C., (Phase I and II); 1600-1500 B.C.,

(Phase III); 1500-1400 B.C., (Phase IV) (Possehl and Rissman In Press:81). Botanical analysis has been carried out and reported by a number of different people, including Vishnu-Mittre (1961, 1963, 1974b), Kajale (1974), and Savithri (1976). A variety of botanical remains were recovered from Navdatoli. The remains mainly represent material from Phases III and IV and are in the form of carbonized seeds. The botanical remains so far identified include wheat, barley, rice, pea, black gram, indistinguishable gram lentil, grass pea, vetch, V. tetrasperma, linseed, myrobalan, jujube, and possibly chickpea (Vishnu-Mittre 1974:3-30). Charcoal representing Dendrocalanus (bamboo) was also observed (Chanchala 1984:157-170). Navdatoli displays a diverse plant based economy involving domesticated grain crops and wild plant collection. Multiple season cropping was also being performed by the inhabitants of this settlement.

Dangwada. The site of Dangwada, located in the Ujjain District of Madhya Pradesh, has Chalcolithic and Early Historic occupations (see: Indian Archaeology, A Review 1978-79:70-71, 1979-80:54-55, 1982-83:59-61). It is the Malwa Phase (1700-1400 B.C.) that is of interest here, where two types of rice: Oryza sativa (628 seeds) and Oryza rufipogon (103 seeds); three types of gram: green gram (183 seeds), black gram (825 seeds) and horse gram (1305 seeds); three types of wheat: Triticum aestivum (23 seeds), Triticum

sphaeroccum (four seeds), and *Triticum compactum* (60 seeds); and eight seeds of jujube and two seeds of lentil were all recovered (Sharma 1983:165-167). Different amounts of these seeds were recovered in each of the Malwa culture sub-phases found at Dangwada. The 3139 seeds from the Malwa phase were recovered from fifteen samples. Archaeobotanical remains from the Early Historic Occupation are not listed here.

Kunjhun. This site is located along the River Son, in Madhya Pradesh, and is associated with corded ware, red ware, black and red ware, black ware and gritty ware (Indian Archaeology, A Review 1981-82:43-44). Some possible rice grain imprints (*O. rufipogon* and *O. nivara*) have been observed in the ceramics from this site (Sharma 1983:85).

REGION V - Ganges Valley.

The final region is the North Central region of India, mainly the area along the Ganges Valley. Twenty-one sites found in four different states will be discussed here: in Bihar (Chirand and Oriyup), in Uttar Pradesh (Kakoria, Magha, Hulas, Laharia-Dih, Sohgaura, Manigera, Mahagara, Baraunka, Atranjikhera, Kaldiwah, Dadupur, Chopan-mando, Mahadah, Un, and Sringaverpur), in Haryana (Daulatpur and Rupar) and in West Bengal (Pandu-Rajar Dhibi and Mashisdal) (figure 3 and table 9).

Table 9. Region V (Bihar, Haryana and W. Bengal) - Main categories of plants by site and time period. CH-Chirand, OR-Oriyup, DA-Daulatpur, RU-Rupar, PRD-Pandu-Rajar Dhibi, MA-Mashisdal.

	BIHAR		HARYANA		W. BENGAL	
	CH	**OR**	**DA**	**RU**	**PRD**	**MA**
CEREALS						
Wheat	H/LH	-	-	H	-	-
Barley	H/LH	-	-	-	-	-
Rice	H/LH	-	LH	H	LH	LH
Millets	-	-	-	H	-	-
Other	-	-	-	-	-	-
LEGUMES						
Peas	H/LH	-	-	-	LH	-
Lentils	H/LH	-	-	-	-	-
Gram	H/LH	-	H	-	-	-
Other	-	-	-	-	-	-
OILSEED/ FIBER						
Linseed	-	-	-	-	-	-
Mustard	-	-	-	-	-	-
Sesame	-	-	-	-	-	-
Cotton	-	-	-	-	-	-
Other	-	-	-	-	-	-
FRUIT						
Melon	-	-	-	-	-	-
Date	-	-	-	-	-	-
Jujube	-	-	-	-	-	-
Grape	-	-	-	-	-	-
Other	-	-	-	-	-	-
TOTAL TAXA	11	1	2	5	2	1

EH-Early Harappan H-Harappan LH-Late Harappan
(as per time period, not cultural phase)

Table 10. Region V (Uttar Pradesh) - Main categories of plants by site and time period. Eight sites from which the only identified plant remains were rice impressions in ceramics are not included. MA-Magha, HU-Hulas, MH-Mahagara, AT-Atranjkhera, DA-Dadupur, CH-Chopani-mando, SR-Sringaverapur.

	MA	HU	MH	AT	DA	CH	SR
CEREALS							
Wheat	-	H/LH	-	LH	-	-	-
Barley	-	H/LH	LH	LH	-	-	LH
Rice	LH	H/LH	LH	LH	LH	EH/H	LH
Millets	LH	H/LH	-	-	LH	-	-
Other	-	H/LH	-	-	-	-	-
LEGUMES							
Peas	-	H/LH	-	-	-	-	-
Lentils	-	-	-	-	-	-	-
Gram	-	H/LH	-	LH	-	-	-
Other	-	H/LH	-	-	-	-	-
OILSEED/ FIBER							
Linseed	-	-	-	-	-	-	-
Mustard	-	-	-	-	-	-	-
Sesame	-	-	-	-	-	-	-
Cotton	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-
FRUIT							
Melon	-	-	-	-	-	-	-
Date	-	-	-	-	-	-	-
Jujube	-	-	-	-	-	-	-
Grape	-	-	-	-	-	-	-
Other	-	-	-	LH	-	-	-
TOTAL TAXA	4	13	3	6	3	2	4

EH-Early Harappan H-Harappan LH-Late Harappan
(as per time period, not cultural phase)

Chirand. At the confluence of the Ghaggar and Ganges Rivers, located in Bihar, is the Neolithic/Chalcolithic site of Chirand (Indian Archaeology, A Review 1963-64:6-8, 1964-65:6-7, 1968-69:5-6, 1970-71:6-7, 1972-73:7-8, 1981-82:13-14). The Neolithic settlement was occupied between 2200 to 1500 B.C. (Chirand I) and the Chalcolithic Period deposits date to 1500-800 B.C. (Chirand II) (Possehl and Rissman In Press:65). There is also an Iron age occupation (Chirand III) which will not be discussed here.

There is evidence of cultivation from all levels including the Neolithic Period. From Period I, wheat, barley, rice, green gram field pea, lentil, grass pea, and sugarcane are represented in the form of charred seeds (Vishnu-Mittre 1974b:3-26, 1974a, 1977). Charcoal belonging to Shorea robusta (sal) was recovered from Period II. Evidence of rice, in the form of charred seeds and husks in pieces of burnt clay represents one of the oldest finds to date of this species.

Oriyup. This site is located in Bihar and has a Neolithic occupation in which rice was identified (Indian Archaeology, A Review 1966-67:6-7). The rice identifications were from impressions in sherds (Savithri 1976).

Daulatpur. The Harappan site of Daulatpur is located in Haryana (Indian Archaeology, A Review 1968-69:8-9, 1976-

77:19, 1977-78:23). The botanical material, in the form of charred seeds, was from the site's Urban and Post-Urban occupations. From the Urban Phase, seeds of black gram were identified (Vishnu-Mittre and Savithri 1982:215) and from the Post-Urban Phase, seeds and husks of rice (<u>Oryza</u> <u>rufipogon</u> and <u>O.</u> <u>sativa</u>) were recovered in charred lumps (Sharma 1983:103-104).

Rupar. From the Harappan settlement of Rupar, located in Haryana, a few botanical remains have been identified (Indian Archaeology, A Review 1953-54:6-7, 1954-55:9; Sharma 1956). Carbonized seeds of wheat, kodo millet and rice have all been found (Savithri 1976:163). Charcoal of <u>Acacia</u> and <u>Albizzia</u> (siris) has also been identified, but they were recovered from a later occupation than the Harappan archaeobotanical remains (Savithri 1976:163).

Koldihwa. Koldihwa is situated along the Belan River in Uttar Pradesh (Indian Archaeology, A Review 1971-72:44, 1973-74:26-27, 1975-76:26-27; Sharma et.al, 1980). Only rice was recovered from this Neolithic/Chalcolithic site. It should be noted that while confusion exists over the dating of this site, Neolithic, Chalcolithic and Iron Age Periods have been identified. Imprints in ceramics have been identified as <u>Oryza</u> <u>rufipogon</u>, <u>O.</u> <u>nivara</u> and <u>O.</u> <u>sativa</u>, all belonging to the Neolithic period (Savithri 1976:141; Vishnu-Mittre

1978b:32; and Sharma 1983:73-75). Only O. sativa has been seen in ceramics associated with the Chalcolithic Period (Savithri 1976:141).

Hulas. Hulas is located in the District of Saharampur, in Uttar Pradesh (Indian Archaeology, A Review 1978-79:60-61, 1979-80:82, 1980-81:73-76, 1981-82:72-74, 1982-83:100-103; Dikshit 1984, 1982). Period I is of interest here because it is from this Harappan occupation that a variety of plant material was recovered. The following carbonized seeds are reported to have been identified from Hulas: one seed of Chenopodium album (goosefoot), three seeds of gram that could not be speciated, two seeds of grass pea, one seed of finger millet, 15 seeds of black gram, seven seeds of green gram, eight seeds of field pea, two seeds of pea, five seeds of horse gram, 18 seeds and impressions in sherds of at least six more rice species, four seeds of wheat, and five seeds of naked barley and four grains of hulled barley (Sharma 1983:99-103). Wheat, barley, beans, peas and some rice are typical components of the diet in Harappan sites of Pakistan.

Kakoria. This Chalcolithic site in Uttar Pradesh contained pottery sherds with impressions of rice. For information on the site see Indian Archaeology, A Review (1962-63:39-41, 1963-64:31-32), and for further information on the

impressions see Sharma (1983), Savithri (1976), Chanchala (1984) and Vishnu-Mittre (1974).

Un. This Late Harappan site in Uttar Pradesh contained pottery sherds with impressions of rice (Sharma 1983; Savithri 1976; Chanchala 1984; Vishnu-Mittre 1974).

Manigera. This Neolithic site in Uttar Pradesh contained pottery sherds with impressions of rice (Sharma 1983, Savithri 1976).

Baraunka. Like Manigera, this is a Neolithic site in Uttar Pradesh with rice impressions in some of the pottery sherds (Sharma 1984, Savithri 1976, Chanchala 1984).

Laharia-Dih. This is a Neolithic site in Uttar Pradesh with many level of occupation (Indian Archaeology, A Review 1980-81:72). The only botanical identifications came from the impressions of rice in pottery temper (Sharma 1983, Savithri 1976, Chanchala 1984).

Sohagaura. This Neolithic site is located in Uttar Pradesh (Indian Archaeology, A Review 1961-62:56, 1974-75:46-47). Pottery sherds from this site contained impressions of rice (Sharma 1983, Savithri 1976, Chanchala 1984, Vishnu-Mittre

1974). No other botanical remains have yet been identified from this site.

Mahagara. Located along the Belam River in Uttar Pradesh is the Neolithic settlement of Mahagara (Indian Archaeology, A Review 1975-76:46-48, 1977-78:52-55, 1982-83:91). The site dates to between 2000 and 1200 B.C. (Possehl and Rissman In Press:36-37). From ceramic impressions, three types of rice have been identified (Sharma 1983:76). Oryza sativa was probably being cultivated at Mahagara. Two carbonized grains of barley have been identified and a fragmentary imprint has been identified as Ischaemum rugosum (Dhanua) (Sharma 1983:77-79).

Magha. This site is located in the Adua Valley in Uttar Pradesh (Indian Archaeology, A Review 1980-81:72-73). From this Chalcolithic/Megalithic site, two carbonized seeds and a number of plant imprints in broken ceramic sherds have been identified. Imprints of rice, showing characteristics of Oryza rufipogon and Oryza sativa, imprints of kodo millet and imprints of seeds of Ischaemum rugosum (Dhanua) have all been identified for the Chalcolithic occupations of Magha (Sharma 1983:107-109). Two well-preserved, carbonized seeds of Echinochloa crus-galli (sawa) were also recovered from Magha's Chalcolithic occupation.

Dadupur. The site of Dadupur is located in the Lucknow District of Uttar Pradesh. From this Chalcolithic site, imprints in ceramic sherds are the only archaeobotanical remains identified. They include Ischaemum rugosum (Dhanua), rice and kodo millet (Sharma 1983:111-113).

Atranjikhera. Located in the Gangetic Plain, in Uttar Pradesh, is the Chalcolithic site of Atranjikhera (Indian Archaeology, A Review 1962-63:34-36, 1963-64:45-49, 1964-65:20-22, 1965-66:44-47, 1968-69:37-38, 1979-1980:75-76). Botanical remains such as rice and chickpea date to around 2000 B.C. (Vishnu-Mittre 1974a and 1974b). Both these plants, in addition to barley, wheat, grass pea, and Boehmeria (China grass) have been identified and dated to 1200 B.C. at Atranjihera (Savithri 1976).

Chopani-Mando. This Mesolithic or Proto-Neolithic site is located in Uttar Pradesh (Indian Archaeology, A Review 1966-67:38, 1977-78:51-52, 1982-83:90-91). Pollen representing grasses and pine (Pinus) were observed in addition to fungal spores. Rice is also reported to be present though it is thought to be wild (Vishnu-Mittre 1974). The dates for the early levels of the site (8000 B.C.) from which rice has been identified is not secure and should be looked upon as questionable (Possehl and Rissman In Press:32-33).

Mahadaha. This site with its microlithis and graves is considered a Mesolithic/Proto-Neolithic site (Indian Archaeology, A Review 1977-78:58-59, 1978-79:59-60) Though the dates of the material is questionable (Possehl and Rissman In Press:32-33), rice representing both wild and cultivated varieties has been identified (Vishnu-Mittre 1974a).

Sringaverapur. On the bank of the Ganga River is the site of Sringaverapura, dating to about 1000 B.C. (Indian Archaeology, A Review 1977-78:54,56, 1978-79:57-59, 1979-80:73-74, 1982-83:91-92, 1983-84:84-85, 1984-85:85-86). The remains of several different taxa were found as impressions in yellowish clay from the first occupational surface of this site. The impressions were identified as rice, barley, sesame and cotton (Saraswat 1981:80-87). All four species were probably being cultivated in the vicinity of the site.

Pandu-Rajar Dhibi. This early farming settlement is located in the eastern Ganges Valley, in West Bengal and dates to between 1500-600 B.C. (Indian Archaeology, A Review 1961-62:59-62, 1962-63:43-46, 1963-64:61-62, 1964-65:46-48, 1984-85:97-98). Archaeobotanical remains were recovered in the from of rice and pigeon pea (Sankalia 1974).

Mashisdal. This farming settlement is also found in the eastern Ganges Valley, in West Bengal and dates to between 1500-600 B.C. (Indian Archaeology, A Review 1963-64:59-60). At Mahisdal, a mass of charred rice was recovered from Period I (Sankalia 1974; Possehl and Rissman In Press:66-67). No other remains have yet been identified.

The Archaeobotanical Variability

As is evident from the preceding review, the total botanical remains (pollen, charcoals, seeds and phytoliths) from Neolithic, Harappan and Chalcolithic sites, from all regions of South Asia, are rather limited. While over 100 different taxa have been identified from these sites, few were found regularly in large concentrations within a single site, and fewer still occurred regularly from site to site, let alone throughout any given region. The taxa found to date by no means represent the extent of the plants being used at any one time or place, they only represent those plants accidently preserved in the archaeological record.

Of the 78 South Asian occupations (from the 69 sites) where plant remains have been recovered, only six date to before 2600 B.C., 22 were from 2600-2000 B.C., and the remaining 50 were from between 2000-1000 B.C. (figure 4). The types and numbers of plant taxa recovered from these

sites appear to vary in both time and space, yet this may as well be a reflection of differential archaeological sampling, as of actual differences in plant usage. Few sites contained more than 10 different recognizable taxa regardless of the site's location or period of occupation (figures 5 and 6). In all, only four sites from all of South Asia have more than 40 different but recognizable species. Either due to preservation factors or methods of collection, few South Asia sites may actually reflect even a fraction of the utilized taxa. The range of sites excavated, their locations, methods of excavation and collection of the plant material, as well as the process of analysis and interpretation, have significant impact on the picture of variability before us. Yet problems and limitations have rarely been used to qualify efforts at paleoethnobotanical reconstruction. To settle these questions and understand the significance of this limited sample, let us first examine the range of taxa so far recovered.

Figure 4. The temporal and spatial distribution of South Asian sites with archaeobotanical finds.

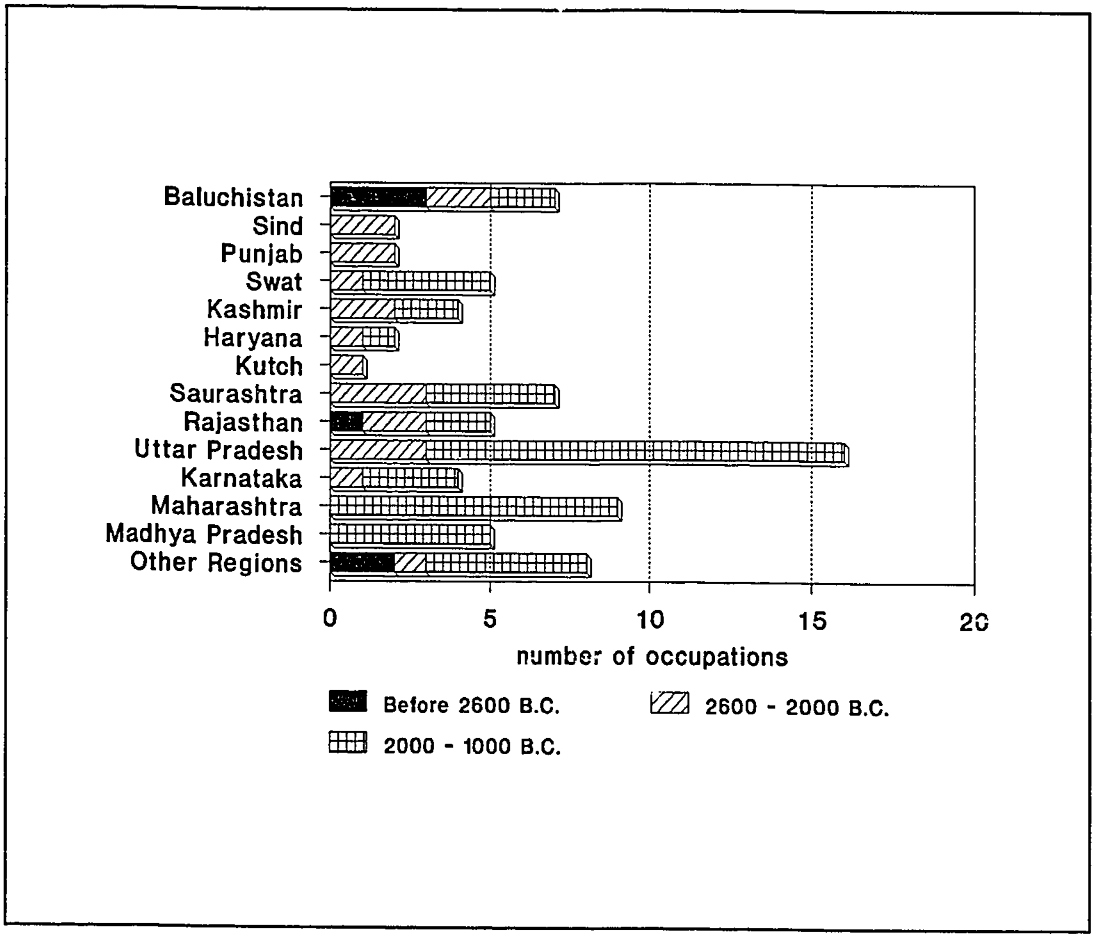


Figure 5. Numbers of taxa recovered from occupations containing archaeobotanical material according to region of South Asia.

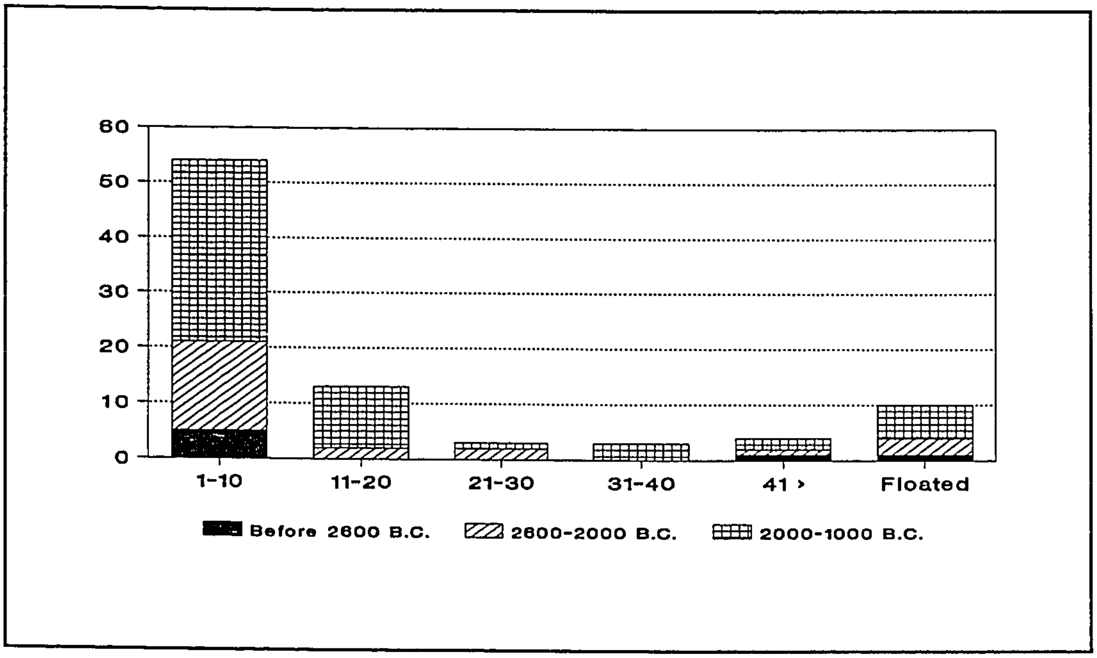
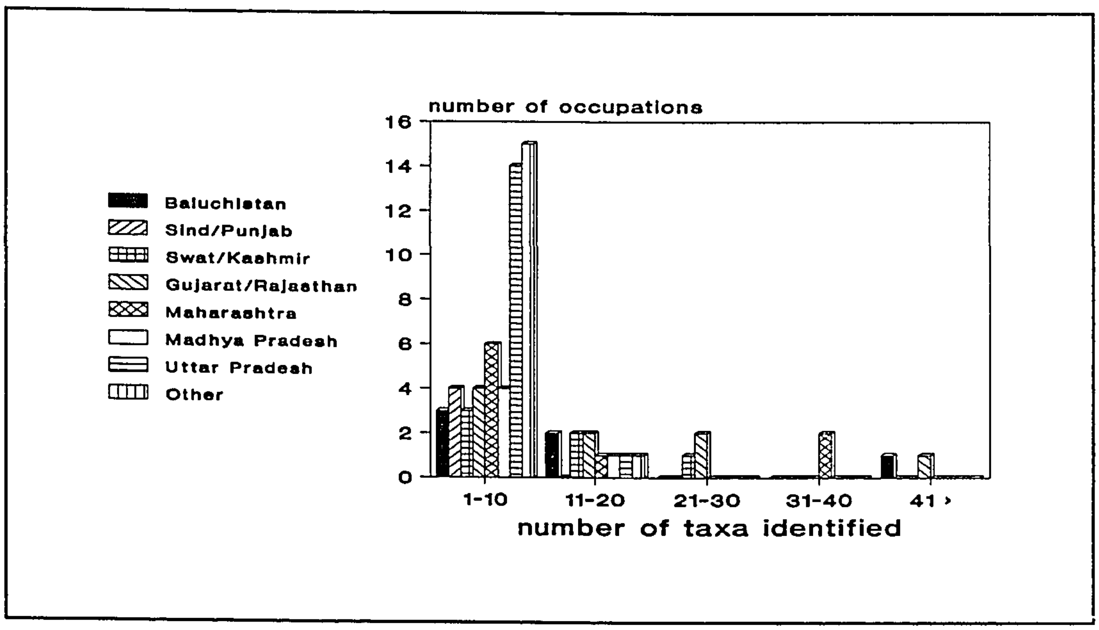


Figure 6. Numbers of taxa identified from occupations containing archaeobotanical material according to time period.



The remains imply the existence of a diet, which while varying to some degree according to region and period of occupation, includes carbohydrates (cereals), proteins (legumes), oilseed and fiber, and fruit. These four groups account for over 80 percent of all the plant material found in South Asia. Over 95 percent of the cereals are wheat (Triticum), barley (Hordeum), rice (Oryza), or millets. Millets are used here to refer to a group of unrelated forage grasses known for their coarse grains and include: Eleusine (ragi or finger millet), Setaria (Italian of foxtail millet), Panicum (little, hog, or common millet), Paspalum (kodo millet), Enchinochloa (sawa millet), Sorghum (jowar, large or great millet), and Pennisetum (bajra or pearl millet).

The legumes divide neatly into peas (Pisum, Cicer, Lathyrus), lentils (Lens), and gram (Dolichos, Phaseolus, Vigna, Medicago). Though few remains can be placed into the oilseed/fiber category it does include such important plants as linseed (Linum), mustard (Brassica), sesame (Sesamum), and cotton (Gossypium). The category under fruit includes melon (Cucumis), date (Phoenix), jujube (Zizyphus), and grape (Vitis).

Regardless of the region (figure 7), the overwhelming majority of the archaeobotanical material belongs in the cereals category (figure 8). Of the cereals, wheat and barley were the most commonly found taxa regardless of the period of occupation, though there is some regional variation

in that they were recovered more often in Indus Valley sites than in any other region (as shown in figure 7). Since some of the earliest settled communities in South Asia yielded wheat and barley, it is difficult to date their initial occurrence in this region. By contrast, the appearance of millets can be more easily associated with a single region and a period of introduction. Further, the commonness of their occurrence seems related to the number of taxa represented at such sites. In other words, in sites where large varieties of taxa were recovered, millets were usually among them. Rice, the remaining cereal grain, usually occurred in the form of isolated finds and rarely in sites where large numbers and varieties of species were found. Rice is also most commonly associated with second millennium sites and in regions where summer cultivation is practiced today.

The legumes represent the second largest category of plant finds which seem to increase in occurrence during the second millennium B.C. (figure 9). Like rice, they seem to be more common after 2000 B.C. and in areas where summer cropping was more popular, such as Gujarat or Central India. Legumes are rarely found as isolated finds, and like millets are commonly found in sites with large numbers of taxa. Again, this may suggest that if extensive archaeobotanical research is performed so that the recovery rate of plant material is increased, then there is an increased possibility that legumes will be represented at a given site.

Figure 7. The numbers of occupations containing various categories of taxa by region.

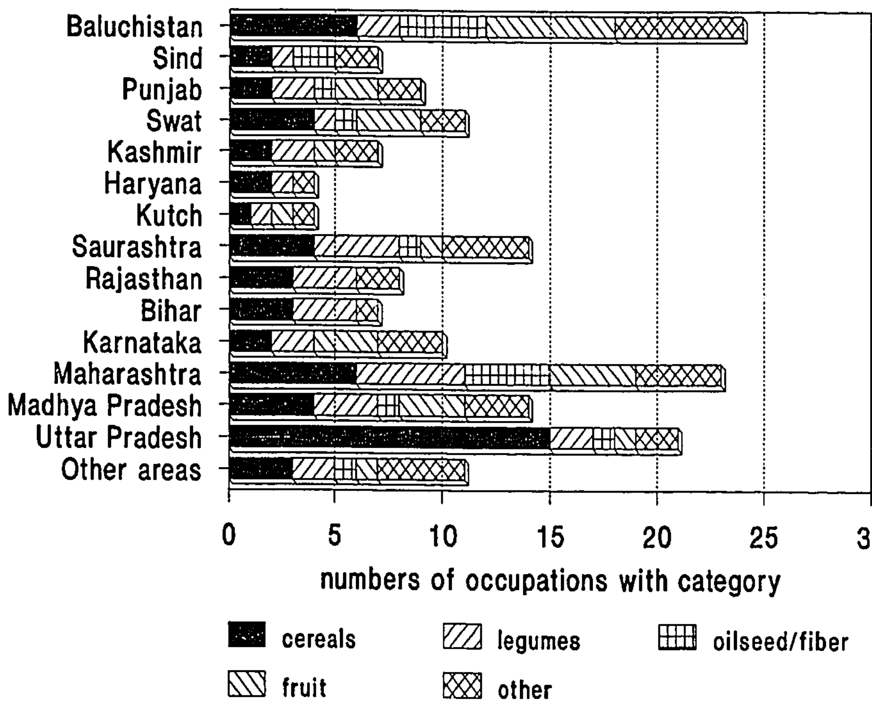


Figure 8. The numbers of occupations in South Asia containing various cereals according to time period.

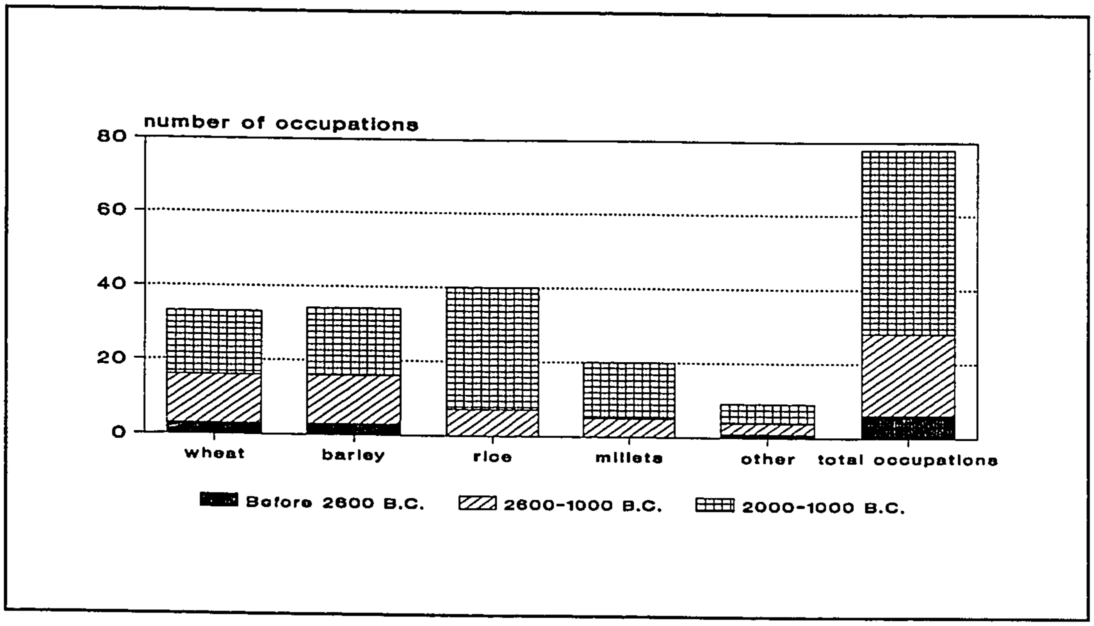


Figure 9. The numbers of occupations in South Asia containing various legumes according to time period.

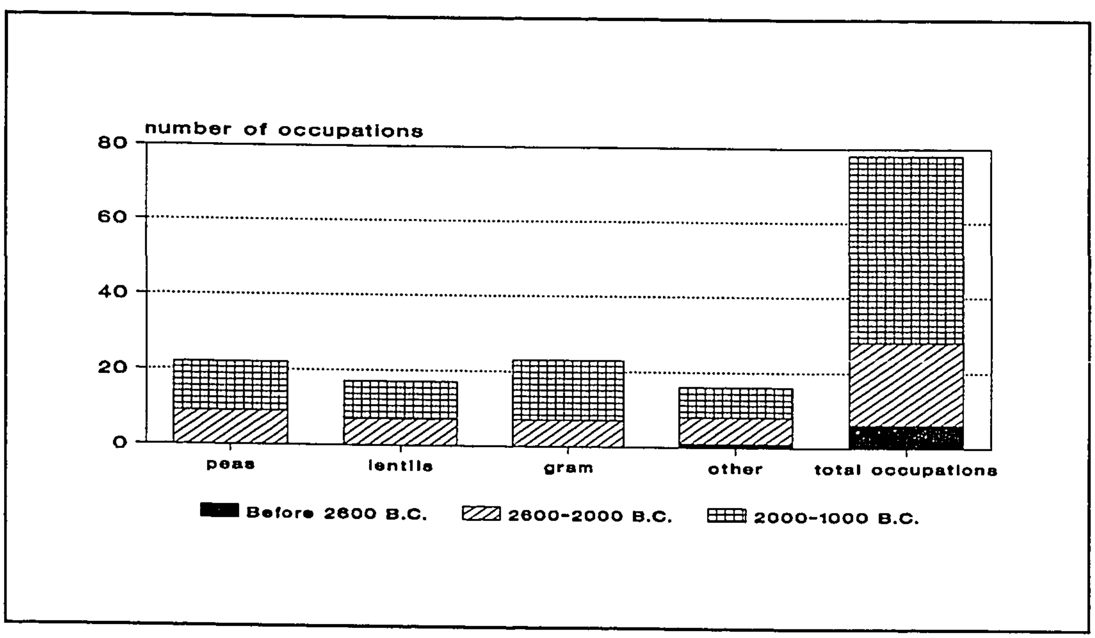


Figure 10. The number of occupations in South Asia containing various oilseed/fiber plants according to time period.

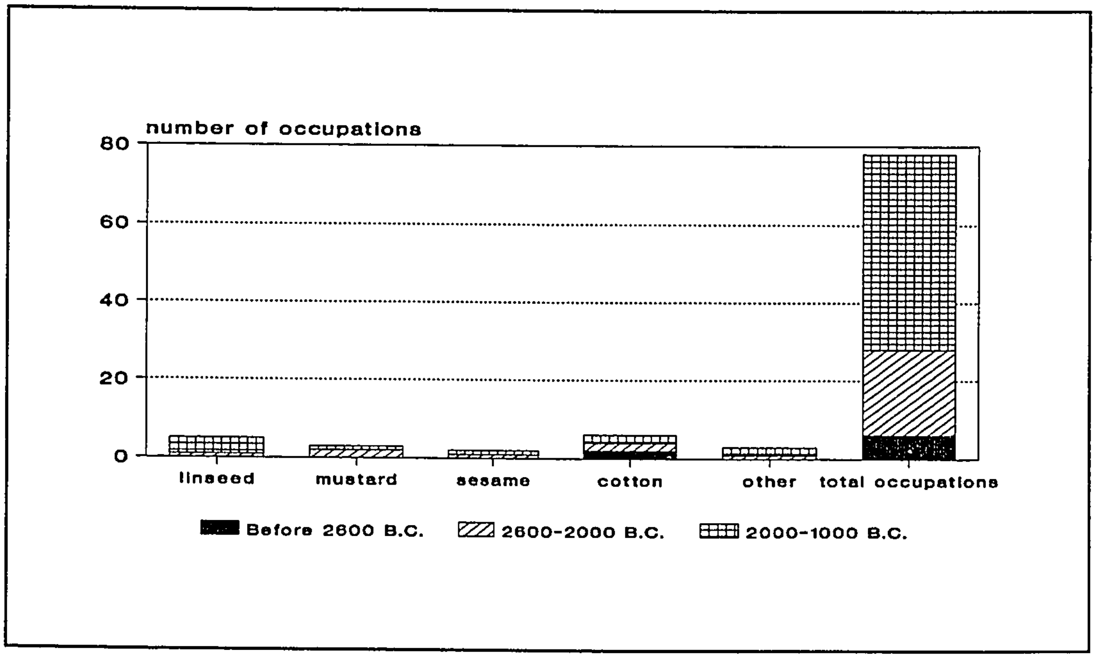
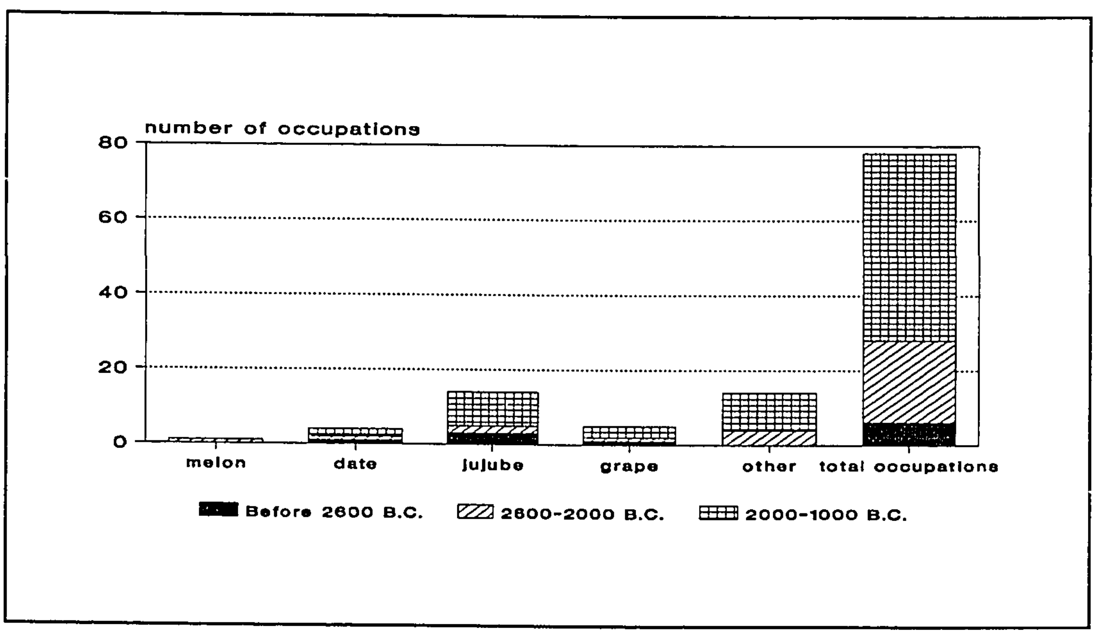


Figure 11. The number of occupations in South Asia containing various fruits according to time period.



Of the final two categories (oilseed/fiber and fruit), only jujube was found in more than five different sites (figures 10 and 11). Because of the low recovery rate, caution should be taken in interpreting the distributional significance of most oilseed, fiber and fruit plant material.

Although reconstruction of Harappan plant-usage strategies and habitat manipulation concerns the most studied and well known Cultural Tradition in South Asian prehistory, it nonetheless suffers from the same problems affecting all paleoethnobotanical studies in South Asia.

Compounding the problem of reconstructing the Harappan food economy is that Harappan culture was not unchanging nor limited to one geographical area, nor were the Harappans the only cultural group in any given region. A further difficulty arises from the differing proportions of Harappan and local traits found in sites identified with the Harappan Cultural Tradition. That is, there is some debate as to which sites are truly Harappan, and thus fit to be included in Harappan subsistence reconstruction.

Less than 30 percent of the occupations correspond temporally to the Mature Phase. Within the territory that is associated with the full extent of the Harappan Civilization, including peripheral regions, irrespective of the date of the occupation, archaeobotanical remains of some form have been recovered from only 33 sites. Of these sites, less than half are unquestionably Harappan and no more than

three were from a single region (e.g. Sind, Punjab, Baluchistan). In all, this makes Harappan paleoethnobotanical interpretation very difficult but not impossible, since certain patterns regarding plant distributions are difficult to ignore, and until more archaeobotanical finds prove otherwise, they can be used in reconstructing a preliminary pattern of plant usage and as a broad environmental indicator.

Harappan Plant Use Strategies

Harappan food economy can be traced to the antecedent cultures in the region just as can be done with the material culture. The finds of fully domesticated wheat and barley from the early Neolithic levels of Mehrgarh are believed to be contemporary with early West Asian Neolithic sites in the Deh Luran plain of Iran and in Syria (McKean 1983:77). These finds imply that cultivation of these crops, the earliest finds of wheat and barley in the subcontinent to date, occurred at least as early as the seventh millennium B.C. From then on, a food producing economy involving domesticated plants and animals, hunting, and plant gathering can be inferred at nearly all Harappan sites.

The number of plants actually cultivated by the Harappans is significantly different from the total number of plants being used by them. Wheat and barley are the most

common crop remains recovered from Harappan sites and subsequently the definition of Harappan Culture has tended to incorporate a wheat and barley subsistence base. Due to the geographical differences represented in the Harappan areas, as well as the regional cultural variations occurring, it is not surprising that past cultivation practices were somewhat variable. Therefore, while wheat and barley did play an important role in Harappan culture, there may have been other major crops as well.

There are two main growing seasons in South Asia. The rabi, or winter season, extends from October to March and the kharif, or summer season, extends from June to October. Wheat and barley do best in a rabi growing season, while many of the millets do best in the kharif season. This may help explain the apparent preferences for millets over wheat and barley in archaeological sites in areas like Gujarat, where the kharif growing season is so popular today (Possehl 1986; Dhavalikar and Possehl 1974). The season of rainfall and the control and management of water are crucial to South Asian agriculture today, and were so in Harappan times as well.

Where rainfall patterns were favorable, and irrigation possible, both a winter crop and a summer crop could have been grown. Winter crops would have included wheat, barley and legumes, while summer crops were rice and most millets. A number of the crops (e.g. cotton, some varieties of gram and millet), could be grown during either season if

appropriate water management systems were in use. While it is likely that the Harappans double cropped at some sites, based on the types of plants recovered, the antiquity of this system is unknown.

The amount and annual distribution of rainfall in South Asia is so unpredictable that systems for the control and management of water were probably important features of the early agricultural economies throughout Pakistan and western India between the second and fourth millennia B.C. (Possehl 1975:34). Not only was river flooding common in many areas within the Harappan Cultural Tradition territory, but its occurrence often increased the agricultural potential and created a need for water control systems (Shaffer 1988:6, In Pressb). Further, it has been suggested that cereal crops grown in flood plains do not need plowing, manuring, or irrigation, although there is no doubt that they grow better and more reliably where these are practiced (Vishnu-Mittre and Savithiri 1982, Lambrick 1964).

Structures associated with cultivation and water control have been noted from a number of different areas in South Asia (Possehl 1975:34). "Gabarbands" (dams) and canals were commonly built to harness, utilize, or slow water and soil movements (Flam 1981a, 1981b; Agrawal 1988:3; McKean 1983:61). They consisted of stone walls, raised earthen banks, brick walls or any combination of these. While the time framework for many of the gabarbands is still debated,

Raikes (1965b:11) suggests that they may date as early as the end of the fourth millennium B.C. Though they served a variety of functions, they are closely associated with efforts at terracing or diverting water in order to retain and distribute silt from flood waters and thereby add to the fertility of the agricultural field (Raikes 1965b).

Harappan fields were probably located near permanent or seasonal water sources where water control would be accomplished by either digging a trench between the river and the fields, by natural overbank flooding, or by use of stone or earthen embankments for water diversion (McKean 1983:88). Fairservis (1982) has hypothesized the use of wells in Harappan agriculture, where water could be pumped in artesian fashion for use in lower-lying fields. In contrast, dry farming is often done today by placing fields in depressed, or low-lying areas where surface runoff will collect. When dry farming is practiced on hill slopes terracing is generally used. Finally, the use of walled fields (bund agriculture) assists in the containment and concentration of moisture (McKean 1983:88).

Other proposals for Harappan water management include Lenshnik's (1973:82) suggestion that the dockyard facility at Lothal was a water storage tank where Persian water lifting devices were used to transport water into irrigation ditches which led to the agricultural fields. Just as there is no physical evidence for this use of the dockyard facility

at Lothal, there is little direct evidence for field preparation or irrigation occurring in any settlement during this time period in South Asia. The Pre-Harappan plowed fields of Kalibangan may be among the few examples of field preparation through furrowing (Lal 1970), although there are difficulties in relating the field in question with such an early occupation phase. This grid-shaped field uncovered at Kalibangan, where furrow marks are still evident, is quite similar to fields found in the region today.

Little evidence exists for the use of fertilizers at Harappan sites. Although manure is commonly used for this purpose throughout much of South Asia today, there is no archaeological evidence for its use in Harappan sites. The discovery of gypsum crystals on a potsherd from Kalibangan have led to the suggestion that it was used for fertilizer, since "ground gypsum is used in agriculture as a surface plaster for conserving moisture in the soil and for aiding nitrogen absorption from manures" (Vishnu-Mittre and Savithri 1982:218).

Natural Environment and Change

Besides dealing with the antiquity, origin and regional diversity of South Asian plants, botanical studies are often used to determine climate and changes in moisture over time through the study of temporal variation of plant remains.

The type of environment and changes that may have occurred play an important part in many theories about Harappan society (e.g. Allchin et al. 1972; Raikes and Dyson 1961; Singh 1971). There is no doubt that a site location is based on certain environmental features (e.g. water), and that any change in climate could drastically alter the way inhabitants live, drive them into another area, or force them to alter an accepted subsistence practice or settlement pattern.

Climate, therefore, tends to delimit the parameters of subsistence and settlement patterns, and changes in habitat can arise as both a natural phenomenon and as a consequence of human-plant interaction (e.g. overgrazing, deforestation). Any shift in climate may have dramatic effects on access to productive resources, as well as the production of many resources.

The climate and environment of the subcontinent during Harappan times has drawn interest and provoked controversy since the earliest excavations in the Indus Valley. Sir John Marshall (1931:2), Rao Bahadur K.N. Dikshit (1938:11), Ernest Mackay (1943:23), and Stuart Piggott (1962:68), all argued that the climate during the proto-historic period was different from that of today. Since then, many studies have been conducted that claim that both during, and since the Harappan period, the climate became alternatively drier, wetter or stayed much the same. Since any climate change could have had a crucial impact on the Harappans, locally and

regionally, a review and appraisal of the theories dealing with climatic reconstruction and change in South Asia is in order.

Theories favoring greater rainfall

A number of researchers have postulated that in the northwest portion of South Asia, the climate during the Harappan period was significantly more moist than conditions found today. Diverse evidence such as the presence of baked brick architecture, Indus seal depiction of certain tropical faunal forms at Mohenjo-daro, the occurrence of drains and gabarbands (dams), which were useful for collecting and carrying off excess rainfall, and pollen profiles (e.g. moisture requirements of taxa represented and higher counts of arboreal pollen) has been used to suggest that there was more rainfall than at present (Marshall 1937; Dikshit 1938; Mackay 1943; Piggott 1962; Singh 1971, 1977; Singh et al. 1972; Sing et al. 1973; Singh and Agrawal 1976).

Singh (1971) has used pollen sequences from lakes in Rajasthan to demonstrate that there was a moister climate in the past. He develops a chronology of four climatic phases occurring in the Indus valley. Beginning with Phase I, prior to 8000 B.C., a period of severe aridity occurs. Then in Phase II, from 8000 to 7500 B.C., a period of increased rainfall appears, creating moister conditions than are found

today. Phase III, from 7500 to 3000 B.C., had less rainfall than Phase II, but overall ecological conditions were similar. Phase IV can be divided into three subphases: IVa, from 3000 to 1800 B.C., sees a dramatic increase in rainfall; IVb, from 1800-1500 B.C., consists of a short dry period; IVc, from 1500 to 1000 B.C., is an arid period with a slight increase in rain. Singh's sequence (1971) implies that during the Urban Phase the Indus Valley received more rainfall than it does today. However, Shaffer and Lichtenstein (1987:8-9) suggest that when the radiocarbon dates used in Singh's climatic reconstruction are recalibrated, a different picture will emerge, one in which Mature Urban Harappan culture will be seen to have occurred during a period of increased aridity, not increased rainfall.

Geological studies have also shown that there was an increase in rainfall in the past, although some imply that the period of increased rainfall was significantly earlier than Singh has stated. Agrawal and Sood argue that a period of sand dune stability, between 4000 and 3000 B.C. suggest a period of increased rainfall followed by the onset of a more arid climate at about 3500 B.C. This decline in moisture may have played a role in the Harappan decline (Agrawal and Sood 1982:225).

The impact of climatic change on the Harappans is referred to in most of these theories. Singh (1971, 1977) argues that the demise of the Indus Civilization was directly

related to decline in rainfall during the early part of the second millennium b.c. Dikshit (1939) proposes that the decline was brought on by a change in the summer monsoon rainfall pattern. Marshall (1931), Mackay (1943) and Piggott (1962) also saw a relationship between changing climatic conditions and changes in the Indus Civilization. Some researchers, such as Allchin and Allchin (1982), regard climatic change as only a minor influence on the Harappans. While climatic fluctuation may have taken place throughout the Holocene, its effects may have been largely local in nature (Allchin and Allchin 1982).

Theories favoring a similar amount of rainfall

Another school of thought holds that climatic change between the Harappan times and the present has been minimal (e.g. Fairservis 1956:359; Raikes and Dyson 1961; Hegde 1977:73; Vishnu-Mittre 1974a, 1982, 1984; Vishnu-Mittre and Robert 1973; Vishnu-Mittre and Sharma 1975). According to these theories, differences in the present and prehistoric environments can be explained using cultural variables such as overgrazing, deforestation, and other poor land management practices.

If the seals do reflect an external reality, there could be two reasons for this. It is possible that these animals had a wider distribution than found today and were

known to the Harappans (Raikes and Dyson 1961:276). The networks of Harappan trade might also have led indirectly to these seal depictions, since perhaps they extended into areas in which the plants and animals we see on the seals flourished. However, the most serious drawback with inferring anything from these seals is to make the assumption that the depiction of faunal and floral forms represents a biological sketch, and not mere pictorial convention.

Arguments for the use of burnt brick at sites like Mohenjo-daro and Harappa can just as easily be explained without arguing for an increase in rainfall. Raikes and Dyson (1961:278) argue that the use of burnt brick might have been simply an adaptation to periodic flooding from the summer monsoon, and not to consistently wetter conditions. Raikes and Dyson (1961) also argue that, considering the size of these large Harappan sites, their drainage systems would have been inadequate to carry off excess rainfall, meaning that the presence of drains in itself does not necessarily imply a greater amount of precipitation in the past.

Further, Raikes and Dyson (1961) and Fairservis (1956) have pointed out that settlement patterns during Harappan times do not imply wetter conditions than those found today. They are argue that different land use patterns may have been in operation, or tectonic changes may have occurred that altered river drainage system. This latter explanation differs from those that account for dry river beds by arguing

that the climate became drier. Today, tectonic movements can be used to explain dried river channels which represent former sources or rivers (e.g. Beas, Sutlej, and Saraswati), or dry rivers themselves (e.g. Ghaggar-Hakra) (Agrawal and Sood 1982; Raikes 1968a; Lambrick 1967). Based on archaeological, geomorphological and hydrological data, it is presently believed that the drying up of these drainages was responsible for this abandonment of certain sites (Mughal 1981, 1982; Pande 1977; Dikshit 1977).

Other scholars point to human induced changes in the habitat and downplay the natural ones. Studies focus on deforestation (Seth 1978), the study of soil in Rajasthan and Gujarat (Hegde 1972) and analysis of faunal and botanical remains from Harappan sites as indicative of open grassy terrains (Agrawal and Sood 1982:223). Vishnu-Mittre (1982) suggests that focusing on climate change is too simplistic and points out that we need to know considerably more about the interaction of environment and culture in order to reach any firm conclusions. Vishnu-Mittre (1974, 1978) has also recommended more study of local environments and questioned Singh's interpretation of pollen sequences, suggesting that more research and data are needed.

Singh's (1971, 1977) Rajasthan pollen data are already the subject of debate by palynologists (Vishnu-Mittre 1972, 1978) and archaeologists (Pande 1977). While Vishnu-Mittre (1974) had argued that the pollen evidence suggests an

increasing aridity during the Holocene, Meher-Homji (1977, 1980) writes that the pollen frequencies are only indicative of local conditions.

Charcoal remains from Harappan sites have been used to identify local flora and subsequently climate and changes in moisture patterns (Seth 1963, 1978; Vishnu-Mittre 1974). Since many of the taxa identified in the charcoal are found in these regions today, and since other flora could have been brought in by trade, they believe that the charcoal remains support the idea of a similar climate to today in prehistoric times. Chowdhury and Ghosh report similar conclusions from Harappa (1951:17), and Seth (1978) from Lothal and Rangpur.

The range of scholarly opinions on the change in climate, or lack of it, since Harappan times precludes any firm conclusions on this subject. The limited data presently available does suggest that the northwestern portion of South Asia did experience a series of climatic changes during the Holocene, but the extent, duration, timing and cultural responses to these climates changes are largely unstudied (Shaffer and Lichtenstein 1987:8).

<u>The Need for Further Paleoethnobotanical Research.</u>

The preceeding discussion demonstrates that while the archaeobotanical record for South Asia is limited and not always very informative, nonetheless some hypotheses about

Harappan plant use and habitat can be made in terms of the range of plants being exploited, what regions are most commonly associated with which taxa, the time periods they are found in, the types of environments they are indicative of, and the types of activities that are generally associated with these taxa. We learn from the few South Asian sites where systematic collection and analysis was carried out successfully, that while the simple presence of a species may signify various distributional characteristics about plant taxa in a region, it tells us little about the relative importance of these plants in the site itself. In order to reconstruct Harappan diets, paleoethnobotanical data must be collected from individual sites in such a way as to optimize the data's use and value.

It is only upon the basis of critical study of the existing database, combined with more paleoethnobotanical analyses of the kind attempted at Rojdi, that reasonable hypotheses can be made about Harappan subsistence, that can, and should be, tested by further work. Giving serious consideration to Harappan plant use, and according it greater analytic signifance that it has enjoyed in the past, will help us understand not only Harappan subsistence strategies, but more about the Harappan Civilization in general.

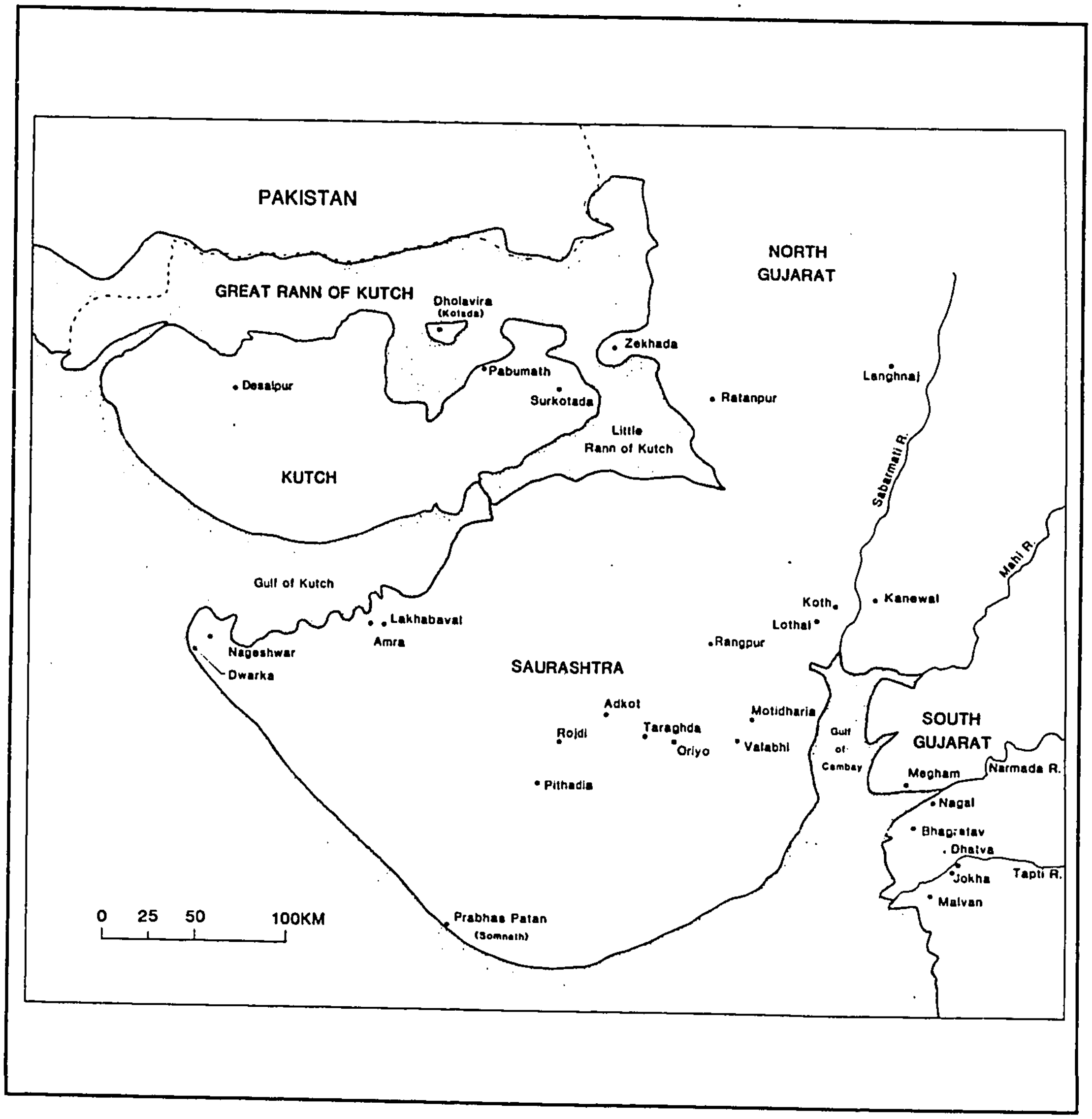
CHAPTER V. THE STUDY AREA

The region in which the site of Rojdi is located will now be examined in its archaeological context in the north west portion of South Asia. The modern Indian state of Gujarat, where Rojdi is located, is approximately coterminous with the southern region of Harappan Culture (Possehl 1980:18). Gujarat is situated on the west coast of India between 20° and 25° north latitude and 68° and 75° east longitude. It encompasses some 187,115 sq km and at its boundaries are the State of Rajasthan on the north east, Madhya Pradesh on the east, Maharashtra on the south east, the Arabian Sea in the west, and the Pakistan border on the north-western fringe (figure 12). Although these boundaries are constructs of modern political divisions, Gujarat is bounded by the sea to the south and west, and by mountains to the east and north. While Gujarat is generally considered a lowland area with an appended peninsula, it does include a variety of environments ranging from the teak forests of the western Ghats to the salt wastes of the Rann of Kutch.

The following discussion of the study area, Gujarat, will be divided into two sections. The first of these will review the physical environment of the region. The focus will be on topography, geology, rainfall, temperature, vegetation patterns and fauna of Gujarat in general. Against

this environmental background, the second section will discuss Rojdi in terms of the structural and artifactual remains recovered, and how best to view the site in terms of temporal, spatial, and cultural frameworks. This later section will discuss the status of all forms of analysis presently being carried out at Rojdi, since these have a bearing on the analysis and subsequent interpretation of botanical material presented in the dissertation.

Figure 12. Map of Gujarat, with archaeological sites, including Rojdi (from Possehl and Raval 1989:7).



Environmental Features of Gujarat

Gujarat is associated with the geologic formation known as the Deccan Trap, which is the basis of the black cotton soils found in the region today. This soil played a significant role in Urban and Post-Urban Harappan settlements, being excellent for dry cropping (Possehl 1980:23-24). The Deccan Trap is a distinctive igneous rock formation (fine grained basalt) which formed as a result of a lava flow during the close of the Cretaceous. This flow, one of the largest in the world, covers most of the what is the today Maharashtra and Gujarat, and the western portion of Madhya Pradesh. Early in the Tertiary, the lava was downthrusted some 2000 meters due to faulting in the Cambay Basin (Patel 1977:22). The Tertiary sediment deposited on top formed the Gujarat Plain. Recent alluvium deposits are a result of sediments brought in by the Sabarmati, Mahi, Tapi and Narmada rivers. Today, soils in Gujarat range from deep black to grey and red. Red soil is typical of what Shaw describes as "deep accumulation of friable detritus found along the lower flats of valleys and in some parts it is rich in ferruginous salts" (1978:3). Along the coast, there is some alluvium though it is often saline.

There are three distinct seasons in Gujarat (winter, summer and monsoon). The hottest months are April and May, with the maximum temperature varying from 37.8°C in the

southern regions to 44.4°C in the central and northern parts. The winter season is November to February, during which the coldest months are December and January. The monsoon months are June to September with the heaviest rainfall occurring in July and August.

The only rain Gujarat receives comes in the monsoon season. While on average 60 cm of precipitation per year may occur in Gujarat, the monsoon may fail to bring any moisture at all. The average annual precipitation is highest in the southernmost regions and gradually decreases to the north.

A variety of animals inhabit Gujarat and while their density may vary from one sub-region to another, there is considerable homogeneity in the animal life throughout the state. Gujarat once abounded in blackbuck (Antilope cervicapra) and chinkara (Gazella dorcas,) as well as larger ungulates such as nilgai (Boselaphus tragocamelus) (Rissman 1986:60). Cervids, including spotted deer (Cervus axis), sambar deer (Cervus unicolor), swamp-deer (Cervus duvanceli), and hog deer (Axis porcinus), are still common in this region. Other animals still occurring are the wild half-ass of Kutch (Equus hemionus), the wild boar (Sus scrofa cristatus), tigers (Felis tigris) in the eastern hills, Asiatic lion (Panthera leo) found in the Gir forest in Saurashtra, and the common hyena (Hyaena hyaena), wolf (Canis lupus pallipes), fox (Vulpes vulpes) and jackal (Canis aureus). Besides the long list of birds and small mammals,

a variety of domesticated animals can also be found in Gujarat, including cattle, sheep, goats, buffalo, dogs and chicken.

While similar types of fauna can be seen in most regions of Gujarat, the marked differences in soil, altitude, temperature and annual precipitation greatly affects the distribution and types of vegetation. Most forested areas lie along the eastern border of the State, some portions of north Gujarat and in the hilly portion of Saurashtra. The dominant plants in these deciduous forests are Tectona grandis, Acacia chundra, Anogeissus latifolia, Butea monosperma, Dendrocalamus strictus, Diospyros melanoxylon, Mitragyna parviflolia, Holarrhena antidysenterica and Wrightia tinctoria (Shaw 1978:6-7).

Scrub forests are widely distributed throughout Gujarat on arid and semiarid zones where rainfall ranges from 25-100 cm per year. Types of plants found in shrub forests include Acacia nilotica, Acacia senegal, Balanites aegyptiaca, Capparis decidua, Capparis sepiaria. Dichrostachys cinerea, Limonia acidissima, and Zizyphus nummularia (Shaw 1978:7).

The bulk of the non-tree shrub vegetation is distributed in specific habitats, for example, wetlands or marshy environments; along river beds or in places of rocky, sandy, moist or water-logged conditions; along the sea shore or in saline ground; or in disturbed areas such as ditches or cultivated fields. Some of the vegetation flourishes

throughout the year, and some includes annuals growing mainly during the short rainy season. There are over 4000 species (Shaw 1978) of plants presently found in Gujarat. For this reason, a more detailed list of Gujarat vegetation will be presented only for the area around Rojdi and will include those plants that are related to the specific issues addressed in this study.

Judging from pollen sequences, the environment of Gujarat has changed little since the mid-Holocene. Pollen cores have been taken from two lakes in western India, Nalsareovar and Malvan, for environmental reconstruction. Both sequences display some inadequacy of preservation. The sequence from Nalsareovar, which is based on six meter cores, dates from pre-5000 B.C. to the present. Grasses dominate the entire sequence, although other taxa include Cyperaceae, Cheno-Ams, Artemisia and Holoptelea (McKean 1983:170). The lower levels indicate a grassland environment with a low density of trees. The middle and upper levels imply the existence of a grassland savanna with occasional brackish flooding. Since the modern pollen record differs little from any levels of this sequence, no significant climatic change is thought to have occurred in Gujarat during the last 7000 years.

The Malvan sequence is dominated by taxa such as Poaceae, (Gramineae), Cyperaceae, Artemisia, Cheno-Ams, Holoptelea, Eugenia, and Fabaceae, (Leguminosae), and

Leguminae, supporting the existence of a type of environment indicated by the Nalsarover pollen. The Malvan lake sequence also suggests little or no change in the environment. A more detailed description of the vegetation, ecology, and paleoenvironment of western India can be found in the works compiled by Agrawal and Pande (1977), Mann (1955), Allchin and Goudie (1971), Allchin et al. (1978), Bahandari (1974), (1978), Bharadwaj (1961), Gupta (1971a, 1971b, 1971c), Gupta and Sharma (1982), Dodia (1988), Dodia et al. (1982), Meher-Homji (1989).

Regional Variation Within Gujarat

Based on geographical criteria and ethnic composition, Gujarat can be divided into four regions: the North Gujarat plain, South Gujarat, Kutch and Saurashtra (Sankalia 1987:ix). These four regions have varied physical and climatic features which impact local populations in different ways, although today there is a measure of cultural and linguistic unity and uniformity. Gujarati is the language most commonly spoken.

The first of the subregions is the North Gujarat plain. This region encompasses the area between the granite hills of Satpura to the east, the metamorphosed schists, gneisses and granites of the Aravallis to the northeast, the Rann of Kutch and the desert of Rajasthan to the north, and the

southern mainland coast. To the west, North Gujarat is bordered by a salt desert and by the low-lying neck of the Kathiawad Peninsula. The soil of this region is described as sandy loam soil (Shaw 1978:4) or alluvial black cotton soil (Gaussem et al. 1968:15), known locally as goradu. The soil in the western portion of North Gujarat has higher percentages of silt and sand, while soils in the north are coarser, shallower and derived from granites. Rainfall in North Gujarat ranges from 40 cm in the west to 80 cm annually in the east. The Sabarmati is the only major river in the region. It flows across the sandy plain from Rajasthan to the Gulf of Cambay. While all other rivers in the region are seasonal, the Sabarmati varies in volume of water over the year but is never totally dry. The floral composition of North Gujarat is similar to the vegetation of the rest of Gujarat, although part of the western portion of this region is a saline and treeless steppe. The vegetation ranges from moist deciduous forests or scrub forests to pure desert conditions (Shah 1978). Types of typical vegetation in the more common tropical thorn forest include <u>Acacia</u>, <u>Capparis</u>, <u>Euphorbia</u>, and <u>Zizyphus</u> with a wide variety of grasses.

The South Gujarat region is the smallest of the four subregions and includes the southern portion of the Gujarat plain. This region is bordered on the west by the Gulf of Cambay and the Arabian Sea, and to the east the granite hills of the Sahyadri and Satpura Ranges. Its southern border,

close to Bombay, is also the southern boundary of Gujarat and its northern border divides the north and south portions of the Gujarat plain. While a number of rivers flow down from these eastern hills (the Northern spurs of the Ghats) toward the Gulf of Cambay, including the Mahi, Dhaddhar, Kim and Tapti, the Narmada (Narbada) which is the best known. The Narmada, one of the largest and most holy of Indian rivers, is the only major river on the subcontinent which flows east to west (Possehl 1980:24). Soil in the subregion of South Gujarat is the black loam variety generally considered to be of high quality. Howver, along the coast to the west it is saline and along the eastern slopes it has little depth. The coastal region is wetter than most regions of Gujarat and subsequently it is more densely covered with an Acacia-Capparis forest. Rainfall in this region of the deciduous forest ranges from 80 to 100 cm annually.

The third subregion of Gujarat, Kutch, is significantly different from the other subregions in terms of vegetation, rainfall and landform (Possehl 1980:28). This subregion consists of a rocky and arid collection of outcrops which are bounded on three sides by the Ranns and adjacent sea coast to the southwest. The Ranns are seasonally flooded salt flats with alluvial deposits of clay and sand. Due to a rise in the level of the Arabian Sea and monsoon induced river flooding, the Ranns are flooded from April to October with salty water up to a depth of about a meter, with occasional

islands of high ground. During this season, it supports a large bird population and a variety of other animals. For much of the dry season, Kutch is a passage for travel between Sind and Gujarat.

Soil in Kutch includes some black cotton soil derived from the weathering of topsoil, as well as loamy sands in the north and south (Gaussem et al. 1968:13). The eastern portion of Kutch has the lowest amount of rainfall for Gujarat with less than 40 cm per year. Most of the vegetation can be divided into salt marshes and mangroves growing in low lying shores and sandy saline areas (see: Shaw 1978 for a complete list).

The fourth and largest of the subregions is Saurashtra, or Kathiawad, comprises peninsular Gujarat. Because Rojdi is located in the center of Saurashtra, this subregion will be described and discussed in greater detail than the other subregions. Saurashtra is bordered by the Arabian Sea to the west, the Gulf of Kutch to the north, the Gulf of Cambay to the south and the marshes of the Nal Depression to the east. The Nal Depression, which presently connects Saurashtra to the mainland of Gujarat, may have been filled up by silting of rivers. This land bridge was flooded for up to six months per year up to as recently as 1813, causing Saurashtra to be an island (Spate and Learmouth 1967). Reports of travelers during the 16th to 18th centuries refer to a branch of the Indus which ran by the town of Cambay and separated

Saurashtra from the mainland (Government of India 1908:170, Rissman 1985:57).

Along the east and west coast of Saurashtra, tertiary clays and sandy limestones are found. In the north, Jurassic limestone occurs and along the south coast, a mixture of alluviae and mulialite is seen (Spate and Learmouth 1967:645). While a number of peaks occur with elevations near 650 m, the highest point on the peninsula is the granite hill of Mount Girnar at a height of 1100 m (Possehl 1980:30). Influenced by the presence of the Deccan trap, the soils of Saurashtra are of the black cotton variety, a residue of its weathered basalt. Coastal soils include a mixture of sandy alluvium and marine mud along the south, and loamy sands in the north (Gaussem et al. 1968:12). Black cotton soil provides the basis for agriculture in Saurashtra (Possehl 1980:30).

Rivers in Saurashtra have their headwaters in the mountain. These rivers flow intermittently and are dependent on the monsoons for much of their water. Rainfall ranges from 40 to 750 cm per year, causing a variety of habitats. Saurashtran vegetation ranges from dry deciduous forest consisting of <u>Anogeissum</u>-<u>Terminalia-Tectona</u> and <u>Acacia</u>-<u>Anogusses</u>, to the smaller vegetation of <u>Acacia</u>-<u>Capparis</u> shrub forests.

Land use in Saurashtra is similar to the rest of Gujarat. Due to the properties of black cotton soil and the

volume of rainfall, Saurashtrans are generally dependent on dry farming. Livestock, including cattle, sheep, goats and buffalos, are raised by most agriculturalists, although specialized migratory pastoralists live in Saurashtra and other subregions of Gujarat. These pastoralists are able to link communities because of their physical mobility and contact with a variety of far-flung settlements (Possehl 1980:30).

The major agricultural season is the kharif monsoon season, and not the winter rabi season which is so important in the Indus Valley. Some agriculture does take place during the rabi season, using irrigation and well water. The black cotton soil is often referred to as 'self-plowing,' since it swells during the monsoon season and shrinks with deep cracks during the dry season (Spate and Learmouth 1967:104). The major cash crops of the present day inhabitants of Saurashtra are cotton, peanuts and tobacco. Subsistence crops are mainly millets during the kharif season and wheat during the rabi season.

Rojdi -- The Physical Environment

Rojdi is located on the northern bank of the Bhadar River in Gondal Taluka, Rajkot District, India (70° 55'E - 21° 25'N). Found near the village of Shrinathgarh, the mound of Rojdi is about 7 ha or 17.5 acres in extent (figure 13).

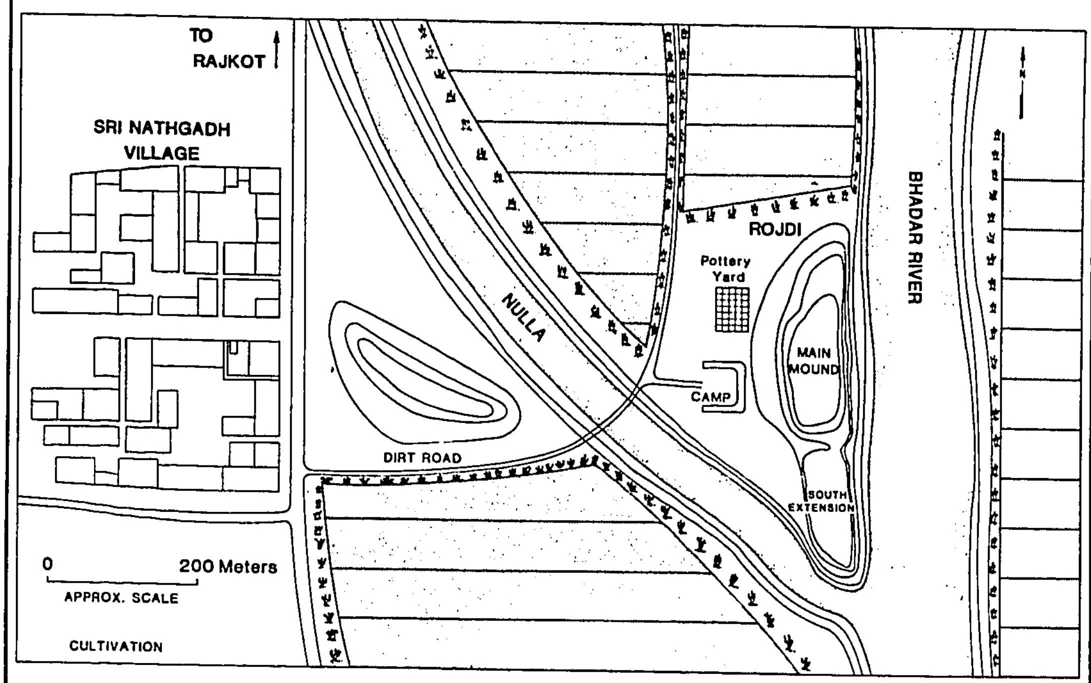
For nearly eight months of the year, or for about 232 days, no rainfall falls on Rojdi and the vicinity (Gaussen et al. 1967). The average annual precipitation for this region of Saurashtra is 60 cm, and it generally falls between mid-June and late September, although it occasionally rains in October and even some of the months of winter. Rain during the monsoon can be so heavy that between 25 and 50 cm will fall in the space of a day. Violent and excessive rainfall often cause floods, while at the other extreme, severe droughts can result from the failure of the monsoon. Such monsoon failure occurred in the past in 1631-1632, 1718-1709, 1731-1732, 1899-1900 -- when less than 10 cm of rain fell, 1911 and in 1934-1940 -- when less than 19 cm fell (Rissman 1985). Most recently, monsoon failure in the mid 1980s caused the Bhadar river to dry up completely. Fluctuation in precipitation has also caused soil erosion, and may have been responsible for the erosion observed on the slope of the mound at Rojdi.

The soil around Rojdi and under the mound is the black cotton variety found on top of the Deccan trap. The temperature is typical for Saurashtra, the hottest month being May when the maximum temperature ranges between 38°C to 40°C. The coldest month is January, with an average low of around 19°C. Frost is not common for this area of Gujarat.

Rojdi is located in shrub savanna vegetation made up of <u>Acacia</u>-<u>Capparis</u> plant community. Trees of <u>Acacia</u> <u>nilotica</u>

and shrubs of Capparis decidua and Zizyphus nummularia, with ground cover of grasses, sedges and herbs, can be found scattered throughout the region. Based on my preliminary observations, this vegetation includes thorny herbs such as Feronia cretica, Echinocarpus echinoides and Solanum surattensis; non-thorny herbs Cassia auriculata, Grephalium luteo-album, Tridax procumbens and Calotropis procera; sedges Cyperus rotundus and Cyperus diformis; and grasses Panicum sp. and Paspalidium flavidum. Also occurring, but not as commonly, are Corchorus depressus, Euphorbia hirta, Aramannia baccifera, Prosopis juliflora, Hemigraphis hirta, Barleria aristat, Commelina benghalensis, Commelina neediflora, Eriacaulon sp., Amaranthus spinosus and Typha sp. Along the edge of the Bhadar River, Febristylis siberiana, Andropogon pumilus, Cyperus pangorei, and Apluda mutica are all growing. Within the river bed itself, Bergia odorata, Sida retusa and Tridax procumbens are all found. Euphorbia merifolia is commonly used today as a field hedge and along with Ipomoea fistulosa is also commonly found along roads and around villages. Commonly found in disturbed grounds and wastelands in the vicinity of villages near Rojdi are Argemone mexicana, Datura inoxia, Jatropha gossipifolia and Opuntia elatior. These taxa are also frequently found as weeds in cultivated fields.

Figure 13. Map of site area (from Possehl and Raval 1989:3).



Present cereal crops in the Gondal Taluka region are wheat, rice, jowar and bajra. Of the legumes, chickpeas are the most common crop, followed by black gram and green gram. Small amounts of acreage are allotted to oil crops such as mustard and sesame, and other species including cumin, coriander, garlic, methi and chilies. The main cash crops are nuts, cotton and sugar cane.

Two crops which were important in the Rojdi of prehistoric times, but are absent from the agricultural practices of present-day Gondal Taluka, are foxtail millet and finger millet. Some wild plants are also used by the inhabitants of this area today, including Cassia auriculata, Withania somnifera, Citrulus colocynthis, Datura inoxia, Boerheavia diffusa, and Cyperus rotundus for medicinal purposes, and Zizyphus nummularia and Capparis decidus for human consumption. Fields are generally irrigated and farm manure is often applied. Mixing of crops and crop rotation is also often practised.

Domesticated animals include bovines, sheep, goats, horses, donkeys, pigs and camels. Bovines, the most common animal, outnumber sheep and goats two to one. Agriculture and herding practices have led to a degradation of the Acacia-Capparis plant community and overgrazing in particular has resulted in a profusion of inferior grasses. The most common plant used for fodder has been variously Acacia, jowar, lucerne (Medicago sativa), Gwar (Cyamopsis

tetragmalob) and a range of wild grasses. Chaff from a variety of domesticated grasses is often mixed with clay and dung to make plaster for wall construction. Finally, dung is commonly used as fuel in the communities presently surrounding Rojdi, and throughout Gujarat.

The Cultural and Material Record at Rojdi

Rojdi, located in the geographical center of Saurashtra, was excavated as an example of a Post-Urban Harappan Tradition settlement, intended to exemplify the florescence of village farming communities in Gujarat. However, it appears that the settlement of Rojdi was established earlier than was originally thought, around 2500 B.C., and lasted for about 700 years (Possehl and Raval 1989).

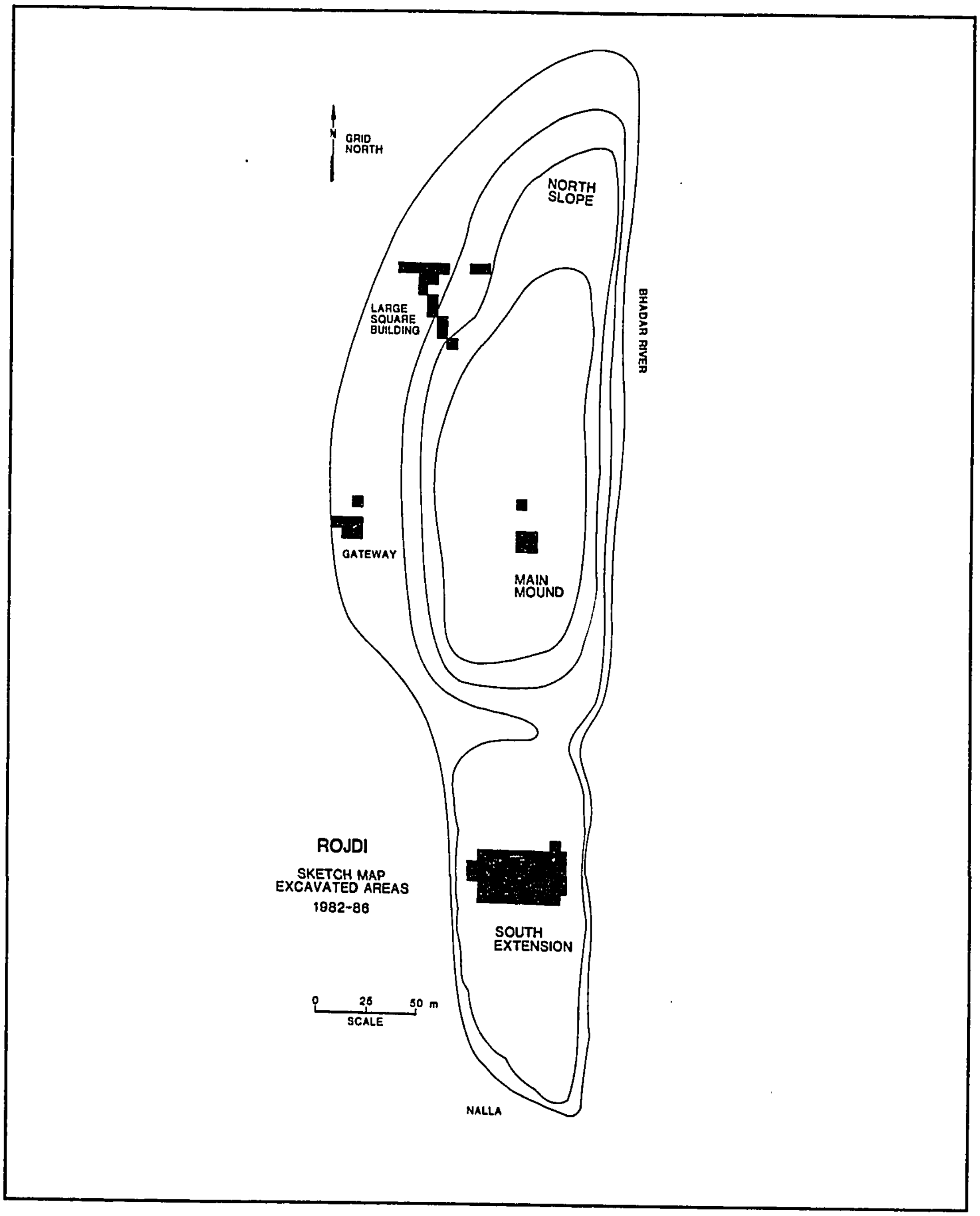
The earliest description of Rojdi, based on information gained after excavation of some areas of the site in the late 1950s, can be found in Indian Archaeology, A Review (1958-59:19-21). The most recent excavations (whence come the data that are the subject of this dissertation), were stimulated by practical interest in the size of the settlement, its location, its good stratigraphy, and theoretical concern with the emergence of the Post-Urban Phase and subsequent changes in settlement and subsistence systems, and shifts in the scale of the stylistic zones of material culture that Rojdi might help illuminate. A number of problem-orientations were

developed around these questions as a means to guide the processes of excavation and interpretation (Possehl and Raval 1989:38-40). Rojdi was excavated in a such a manner as to expose a variety of functional areas within the site. Four different parts of the site were sampled in order to get a representation of the range of activities occurring at Rojdi (figure 18). The four principle excavation areas are referred to as the Gateway, the North Slope, the South Extension and the Main Mound. Soil from each of the areas was screened through a one quarter-inch mesh screen (except for the pollen and flotation samples which were processed in different ways). All recovered artifacts were saved and recorded. A more detailed description of methods will appear in Chapter VI.

Areas of Excavation

The following description of the four areas of excavation are summaries based on various reports and manuscripts which will not be individually referenced (figure 14). For further information about these areas including more detailed description of the architecture, material finds and their interpretation, see Possehl and Rawal (1989), Possehl et al. (1984, 1985) and Possehl and Herman (In Press).

Figure 14. Map of Rojdi, showing excavated areas (from Possehl and Raval 1989:5).



The Gateway. A wall appears to have bordered all but the eastern edge of Rojdi. A line of large basalt boulders running along the western edge of the site are the remaining foundation of this wall. A gateway along the south-central portion of this wall could also be seen on the surface based upon the stone patterning. During the 1982-1983 season, the gateway and adjacent portions of the wall were excavated. Since portions of the wall appear to have been removed by erosion, it is unknown whether the wall originally ringed the site entirely.

The large basalt boulders (some weighing more than a metric ton) were placed side by side, one to two meters apart, forming a double line where one formed the inside, and the other the outside boundaries of the wall and Gateway foundations. Between these boulders, compacted earth and smaller stones were placed. It also appears these large foundation boulders were placed in a shallow trench. Only small numbers of Harappan Red Ware sherds were recovered during the excavation of this area. Due to the size and weight of the boulders, as well as the likelihood that the wall enclosed the entire settlement with the exception of the river side, the wall and Gateway may be regarded as an example of monumental architecture.

The limited number of soil samples were collected from this area yielded few botanical remains (see below).

North Slope. The North Slope of the site consists of the northern areas of the site and "The Large Square Building". While these areas are often discussed separately, in this work they will be grouped together due to their close proximity to one another and because they were excavated in the same seasons, commencing in 1982-83.

In the first season, a trench connecting the outside face of the large square building's north wall to the wall which encloses the western edge of the site was excavated. The trench was two meters wide by 20 meters long and provided a profile showing the strata between the wall and the large square building. This trench showed that the foundations of the site wall and of the building were both constructed on the same hard layer of black cotton soil (Possehl et al. 1985:89). Since the construction technique of the wall and building also appear basically the same, we think that these features were constructed at about the same time.

In the 1983-84 season, the interior of the square building and a trench connecting the southern wall of the building to the north slope of the Main Mound were excavated. In an effort to determine the function of this building, the interior was excavated in an area of 15 m^2. The mass of debris associated with the interior of the building consisted of Harappan pottery, stone rubble, lumps of burned clay and boulders belonging to upper parts of the structures. Two distinctive phases of building collapse are implied by the

remains. The first phase of collapse is based on the debris lying directly on the foundation layer. Associated with the soil above this first layer of deterioration are fragments of large storage jars, principally buff ware and often painted. These sherds were in the structure at the time of the wall collapse representing the second phase of deterioration. At present, it still has not been determined whether the sherds between the two phases of structure collapse represent a dump for broken pottery or a storage area with complete storage jars. Salient facts for the resolution of this question include the high percentage of buff storage jar sherds in this location that are not found in trash contexts at Rojdi; and the absence of animal bones that make up a high proportion of the refuse at the site. Analysis of the botanical remains has contributed to the debate, suggesting the use of the building for storage (discussed below).

The second area on the north slope excavated during the 1983-84 season consisted of a 15 m trench from the southern wall of the large square building to what appears to have been a retaining wall in the northwest corner of the Main Mound. Since the strata in which the retaining wall was constructed rests 50 cm above those of the large square building, we have concluded that the building was constructed before the retaining wall. One interpretation is that the settlement had been expanding toward the large square

building during its use and that the retaining wall marks the maximum expansion of the settlement in this area of the site. Finally, this trench revealed some of the earliest evidence of human activity in the site, a hollow or pit filled with trash (e.g. pottery, animal bones and plant remains) on top of which some portion of the building may have been placed.

South Extension. What has become known as the South Extension is the southern portion of Rojdi where rock alignments on the surface indicate the presence of a number of different but connected structures. Over 1000 m^2 of the South extension has been excavated during three seasons of work.

The earliest remains uncovered in this part of the site were in an area used as a trash dump. A series of trash pits rich in ceramics, animal bones and plant remains were uncovered at a depth of up to two meters below the surface. These pits were dug into sterile soil and were easily visible in profiles. The pottery remains were local varieties of Harappan types consisting of fine red wares, fine buff ware, coarse black and red ware and other coarse wares. The overwhelming homogeneity of the ceramics in these pits may be due to the short period of their use.

Overlying these trash pits are two building levels. The lower of these levels is referred to as Phase I and is represented by a curved wall foundation. This curvilinear

structure, the only one so far found at Rojdi, is about 20 m^2 in diameter. Phase I does not seem widespread.

Above Phase I is the uppermost building level (Phase II) found at the South Extension. Phase II has at least two subphases which are referred to as IIa and IIb. Phase IIb represents the final period of architectural activity found on the South Extension. Again, ceramics from Phase II are regional varieties of Harappan Wares. A number of complete, in situ, Harappan vessels were also recovered from this phase of activity. The buildings associated with Phase II are made of basalt boulders in a number of courses still resting on top of one another. The structures vary in size and shape, with external dimensions in excess of 12 m by 14 m (168 m^2). The walls of these buildings are laid out in a manner which shows a common orientation and a regularity, implying a high degree of community organization and planning. This type of community organization is commonly associated with the Urban Phase Harappans. The subphases of "a" and "b" are derived from the architectural modifications observed in the course of the excavation of Structure I, the triangular building.

The Main Mound. Excavation on the Main Mound consists of four 5 m by five meter trenches, two of which went down to sterile soil. Excavation of this area took place over three seasons (1982-83, 1984-85, 1985-86). The longest sequence of Rojdi occupation comes from the Main Mound and is best

observed in Trenches 46L and 45K. Based on the excavation of these two trenches, nearly three meters deep, a series of occupations and building levels can be identified. Two main architectural levels have been identified occurring in this part of the site, both of which were divided into two subphases (1a, 1b, 2a, and 2b).

A hard, well compacted flat surface was initially made on sterile soil and marks the beginning of human activities on this portion of Rojdi. The floor was constructed with a dark brown earth and capped with a lighter, hard earth. Of the few remains recovered associated with this surface was a poorly preserved infant skeleton. The extent of the floor is unknown since it extended into all of the baulks of 45K, the only trench within which it was observed. This floor, a hearth and some rock alignments in 46L are the elements of the first architectural subphase (1a) on the Main Mound.

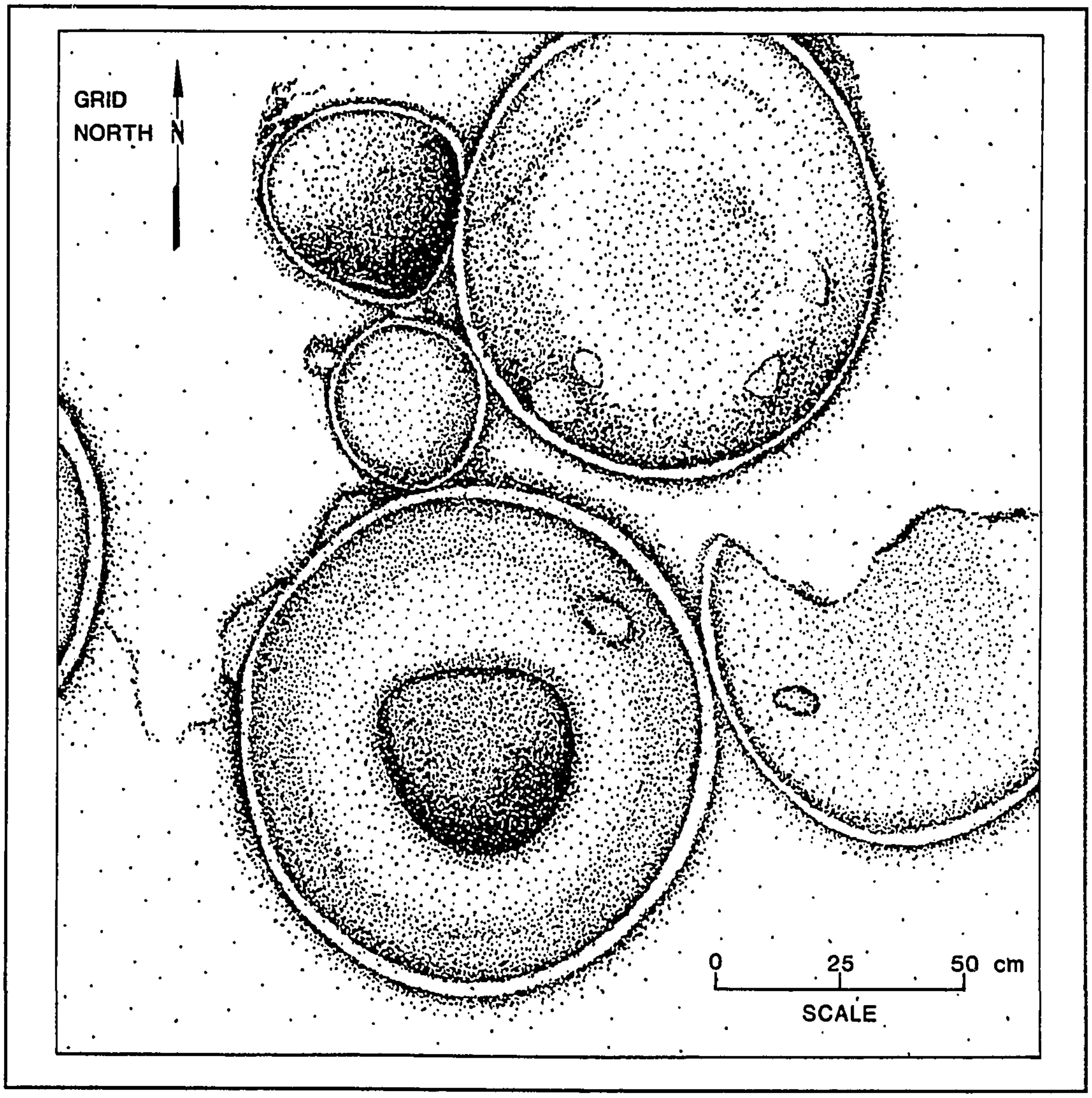
The next subphase starts above a thin layer of fill. The architectural features associated with 1b are a series of "bins" found in 45K, and series of thin floors excavated in trench 46L. The term "bins" has been applied to a cluster of circular, dish or shallow bowl-shaped features measuring about 1.75 cm across and 20 to 30 cm in depth (figure 15). They are generally constructed of a fine clay and sand mixture about 2 cm thick in a continuous manner with edges resting 10 cm above the floor, a height they do not seem to have exceeded while in use. One of the bins has a hole in

the direct center, but its significance, like the function of the bins as a group, is unknown. The fill directly above these features contained large numbers of small rodent bones, many of which appear burned.

Architectural subphase 2a consists of the remnants of a building in 45L. All that is exposed of this building subphase is a multi-coursed stone wall. About 2 cm of fill separate 2a from 2b. A large rectangular building, representing one of the major building levels at Rojdi, comprises subphase 2b. One Harappan Red Ware pot set into the floor, and two Harappan copper/bronze tools (an axe and bar celt) are associated with this structure. Its walls were made of basalt boulders, and in places, as many as 5 courses remain intact. This large building represents the upper-most Harappan building levels found to date in the Main Mound.

A poorly preserved Medieval occupation was observed along the upper levels of the Main Mound. This occupation is represented by some rock alignments and trash pits, some of which were dug sufficiently deep as to contaminate the Harappan levels, making the interpretation of the upper levels of Harappan occupation difficult.

Figure 15. Drawing of bins in Trench 45K (from Possehl and Raval 1989:44).



Material Remains

The following brief summary of material remains at Rojdi will be broken down into discussions of the ceramics, lithics, ground stone, small finds, faunal and botanical remains.

Rojdi Ceramics. The ceramics represent a single pottery tradition consisting of wheel-thrown vessels referred to as fine wares and coarse wares. Although this material is still under study by Charles Frank Herman, it is sufficiently advanced that some general trends can be observed. The following summary of ceramic finds and their interpretation is from Herman (1989:56-96) and Possehl and Herman (In Press). It will focus on the deep trenches of the Main Mound (46L) and of the South Extension (76N) and is necessarily preliminary in nature.

Fine Red Ware, Fine Buff Ware, Fine Grey Ware, coarse Black-and-Red Ware, Coarse Red Ware, Coarse Grey Ware and Crude Buff Ware are all present from the earliest levels of occupation. However, techniques in construction and decoration, and distribution of various vessel forms vary and change throughout the occupation. Other more regional pottery types like the Smooth Red Ware, Micaceous Red Ware, and Prabhas Ware are found in small amounts in all periods of occupation. Compared to the Fine Black-and-Red Ware,

Lustrous Red Ware is rare at all levels of Rojdi, and is absent in the initial phase of occupation.

Herman has divided the Rojdi ceramics into three phases (Rojdi A, B, and C), based on the ceramic fabric, form, decoration and distribution. Rojdi A is the earliest pottery phase and is subdivided into A1 and A2. Resting on sterile soil, Rojdi A1 differs from A2 in that it lacks the straight-sided bowls which appear in small quantities in A2. Rojdi A2 also shows an increase in the percentage of bowls, decorated pottery and total number of sherds. Post-firing graffiti, almost absent in A1, also becomes more popular in A2 and throughout the other phases.

Pottery of Rojdi A belongs to the Urban Harappan Period where the Fine Red, Fine Buff and Fine Grey Wares are part of the Greater Indus Valley ceramic tradition. Although quite limited, the range of vessel forms of the fine wares from Period A consist of mainly bowls, small to medium sized pots, jars, basins, dishes and the dishes-on-stands. The coarse wares from Rojdi A are unlike coarse wares from Harappan sites outside Gujarat. Finally it should be noted that the vessel forms of Rangpur IIA are similar to those of Rojdi A.

Rojdi B ceramics represent a transition period between A and C, although they are in general more like the assemblages of A than C. Besides a number of new vessel forms being introduced at this time, Rojdi B includes new

painted design elements which continue into succeeding ceramic periods. This transition phase is associated with the latter part of the Urban Harappan Period.

The fine wares (Fine Red, Fine Buff and Fine Grey) are the dominant ceramics of Period B, where they make up nearly 80 percent of recovered rim sherds. Although the convex-sided bowl dominates the assemblage as it did in Period A, there appears a broader range of vessel forms. Motif designs, including all forms of decoration on the fine ware vessels, differ slightly from the preceding level. Burnishing decreases as a method of decoration and a few geometric motifs like oblique lines, wavy lines flanked on both sides by a hanging curve, and diamond shapes decline as well. These changes occur toward the end of this ceramic period. Graffiti continues to occur on one percent of the sherds, the only difference being that it now only appears on the exterior of pots.

Like the fine wares, the Rojdi B coarse wares appear in a greater variety of shapes and sizes than in Rojdi A. The coarse wares in Period B appear to be inferior in hardness and durability. The increase in variability is matched by a decrease in number of recovered coarse ware sherds, with the exception of coarse Red Ware sherds, which increase in quantity in Period B. Vessels such as medium sized storage jars, tall basins and dishes are clearly part of the ceramic assemblage of Period B. Coarse ware decoration and surface

treatment is essentially the same in Rojdi A and B, except for innovations such as thumb impressions combined with burnished lines.

Ceramics from the upper levels of Rojdi are characteristic of the early Post-Urban Phase and are discussed here as Period C. While the pottery from this period bears many similarities to that of Rojdi A and B, there are significant differences in the variety and complexity of the shapes and design of the vessels. For example, the fabric and firing quality appears to deteriorate and style of decoration becomes more open.

Rojdi C fine wares display a mixture of old and new forms with convex-sided bowls continuing as the major ceramic type. New forms include S-shaped bowls, straight-sided bowls, open-mouthed storage jars and basins, large close-mouthed storage vessels, medium sized vessels (pots and jars), with both restricted and unrestricted shoulders and nearly straight walls, jar stands, and the "Saurashtran lamp." These fine wares are often coarser, have slips which are heavily pitted and show inferior firing compared to fine wares from earlier periods. Almost all fine ware vessels of Period C are slipped and more are decorated than was the case in previous periods. Painted designs, burnishing and graffiti all increase in occurrence. Geometric and non-geometric motifs appear regularly. Although rare, stylized

representations of plants and animals appear for the first time.

Coarse wares decrease in quantity from 24 percent in Rojdi B to nine percent in Rojdi C. New forms of large storage jars, pots, dishes and basins appear along many of the previous forms. The Saurashtran lamp and dishes-on-stands also appear in the coarse ware assemblage for Rojdi C. As a whole, the coarse wares from Period C retain their previous fabric but are not as well fired as in the previous phases.

While common Mature Harappan ceramics such as the goblet, beaker, and S-shaped jar have not been found at Rojdi, and only a single sherd with the Indus black-on-red painting style has been recovered, there are enough ceramic similarities to associate this site with the Harappan Tradition, albeit as a regional variant. Arguing on the basis of the ceramics represented by Rojdi A and B (and possibly also by the early Rangpur ceramics), a regionally influenced Urban Harappan style called the Sorath Harappan has been suggested for the the third millennium B.C. Other Saurashtran sites from this period, including Desalpur, Surkotada and Lothal, contain different types of ceramics from Rojdi, yet show Harappan characteristics. This has led to the creation of a second category, named the Sindhi Harappan (for a more detailed discussion of these regional Harappan styles see Possehl and Herman In Press).

Rojdi Lithics. A variety of lithic artifacts (tools and debitage) were recovered from all locations in the course of excavations. Two main categories of tools can be identified, flaked stone and ground stone. Flaked stone artifacts consist generally of blades, blade-like flakes and blade cores. The flaking material includes chalcedony, chert, sithstone, jasper, quartzite, and basalt. The ground stone artifacts include handstones, querns, ground slabs, stone "balls" and disks, polishing or sharpening stones, and other stones which show various degrees of grinding due to use. Many of the stones are fragmented and serve an unidentified function. The predominant grinding material is basalt. The most common grinding stones are bifacially ground handstones with convex grinding surfaces, querns or quern fragments, and grinding slabs. Some of the quern grinding surfaces measured more than 60 by 40 cm.

The lithic artifacts from Rojdi are still being analyzed, so the information about these finds is presently limited. The pollen washes from the surfaces of many of the ground stones are also under analysis.

Small Finds. A variety of artifacts from throughout Rojdi are identified as small finds, and are significant in that they represent various technologies, trading activities, and influences from outside Rojdi. The finds include metal artifacts, terracotta discs, rings, wheels, beads, cubes,

figurines, stone weights, and beads of shell, limestone and carnelian. Few of these small finds have been analyzed.

To date, no metallurgical analysis has been performed on the copper-based metal implements recovered from Rojdi. These metal artifacts include a copper axe, bar celt, bangles, rings, a fish-hook, pieces of wire and one pin. One of the most interesting finds was a copper parsee or knife with an endless knot design. This design is known from Harappan contexts like Mohenjo-daro and represents the first such find in Gujarat. It is used in South India today as a sign associated with good beginnings, openings and new events (Possehl et al 1985:92-93).

Faunal Remains. A large collection of animal remains in the form of bones, teeth and shell have been recovered from Rojdi. The analysis of this material is in a preliminary state. A summary of what is available will be presented here and is from two sources, Crabtree's (1985: 94-97) analysis of the material from the 1983-84 field season, and Kane's (1989: 123-129).

Only the mammalian bones have been studied so far and therefore the following discussion will focus on this material. Despite a majority of the remains being made up of unidentifiable fragments, a sizeable quantity of the remains could be identified. Between roughly 75 and 80 percent of the identifiable mammalian remains from Rojdi were

large domestic bovids (table 11). The most common taxa was Bos sp.(domesticated cattle).

Table 11. Rojdi Animal Remains.

Bovidae.	Bos sp.	Domestic cattle
	Bubalus bubalus domesticus	Water buffalo
	Ovis sp.	Sheep
	Capra sp.	Goat
	Boselephas tragocamelus	Blue bull
	*Tetracerus quadricornus	
	Antelope cervicapra	Black buck antelope
	Gazella gazella	Gazelle
	Bos indicus	Indian zebu - humped cattle
Cervidae.	Axis porcinus	Hog-deer
	*Axis axis	Spotted Deer
	Cervus duvauceli	Swamp-deer
	*Cervus unicolor	Sambar Deer
Suidae.	Sus scrofa cristatus	Domestic pig
	Sus scrofa	Wild pig
Canidae.	Canis familiaris	Domestic dog
	Cuon alpinus	Indian dhola
	Canis aureus	Jackal
Felidae.	Felix lybica	Desert cat
	Felix catus	Domestic cat
Other.	Lepus nigricollis	Indian hare
	Equus hemionis	Wild ass
	Elephas maximus	Indian elephant
	Camelus dromedarius	Camel
	Hystrix indica	Indian crested porcupine
	Rattus sp.	Rodents
	Trionyx sp.	Tortoise (shell)
	Gallus sp.	Domestic fowl

Also jaw of a lizard, fish vertebrae, variety of shell, and variety of birds.

Other members of the Bovidae family represented in the Rojdi records were Bubalus bubalus domesticus (water buffalo), Ovis sp. (sheep), Capra sp. (goat), Gazella gazella (gazelle), and possibly Bos indicus (Indian zebu or humped cattle). Based on the total number of bones identified for each species, the total number of fragments identified for each species, and calculations such as Minimum Number of Individuals (MNI), ratios were calculated that indicate that cattle were the most common faunal remains at Rojdi, followed by sheep and goats, and then by pigs (figure 16).

Some estimates of the ages at death of the cattle from Rojdi have been performed (Crabtree 1985:96). Based on epiphyseal fusion of the long bones, Crabtree concludes that about five percent of the cattle were killed during the first year and half of life, almost 20 percent had been killed by three years, and just under 50 percent of the cattle had been killed by four years (figure 17).

The next most common mammalian remains at Rojdi were the those of Cervids and Suids, each representing about eight to 10 percent of the total bones. The types of Cervidae presently identified are thought to include four species of deer (Axis porcinus, Axis axis, Cervus duvaceli and Cervus unicolor). The Suidae are represented by domestic pig (Sus scrofa cristatus) and wild pig (Sus scrofa). Five to nine percent (the remaining identifiable bones) of the Rojdi faunal record is made up of a diverse set of animals, none

of which are represented by more than a few bones. These include the domestic dog (Canis familiaris), jackal (Canis aureus), desert cat (Felix lybica), domestic cat (Felix catus), Indian hare (Lepus nigricollis), wild ass (Equus hemionus), Indian elephant (Elephas maximus), camel (Camelus dromedarius), Indian crested porcupine (Hystrix indica), various rodents (Rattus sp.), tortoise (Trionyx sp.), domestic fowl (Gallus sp.) and other various birds, fish, and shelled animals.

Because of the great volume, variety and good preservation of the identified remains, as well as the presence of both wild and domestic species, it is expected that the faunal record will make a profound contribution to our knowledge of hunting patterns and animal husbandry practices, and will allow us to determine the relative importance of the species present. Since it is difficult to discuss the floral remains without reference to faunal ones, hypotheses proposed in following chapters will be based on certain preliminary conclusions about the significance of the animal record at Rojdi. Definitive statements about the complete subsistence picture at Rojdi must await the completion of the faunal analysis.

Figure 16. Species ratios of domesticated mammals at Rojdi (Source: Crabtree 1984).

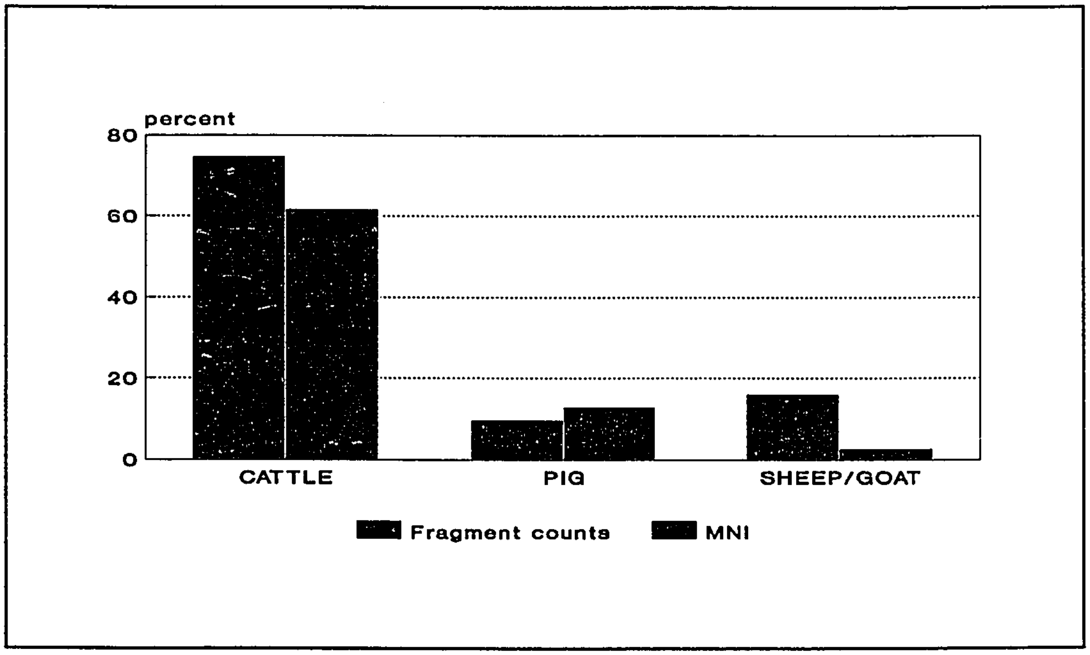
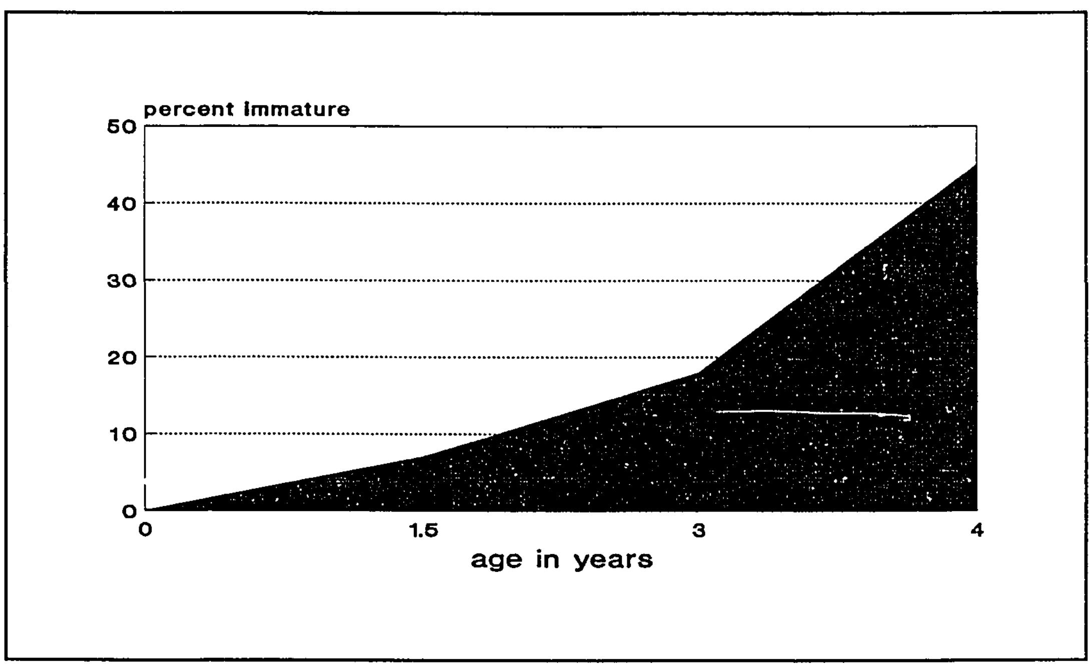


Figure 17. Cattle kill patterns based on epiphyseal fusion (Source: Crabtree 1984).



Floral Remains. The plant remains from Rojdi come in a variety of shapes and sizes. Some of them are burned, others are unburned. They range from microscopic pollen grains, phytoliths and small seeds to clearly visible items such as large seeds, twigs, stems or pieces of wood. The seed collection recovered from Rojdi is extraordinarily rich and forms the basis of the research presented in this work. Since the remaining portions of this dissertation focus on the archaeobotanical remains at Rojdi, further discussion at this point is not warranted.

Rojdi Chronology

Besides the Rojdi ceramic chronology developed by Herman (1989), a time scale for Rojdi has also been derived from a series of radiocarbon dates. Twelve radiocarbon determinations (table 12) place Rojdi solidly in the Urban and early Post-Urban Phases (Possehl and Raval 1989). Using only recalibrated radiocarbon dates, in association with the existing interpretation of the architectural and ceramic phases, the Rojdi chronology can be constructed (table 13). Four time periods have been defined, (termed Rojdi A, B, C and D), which provide the framework for the analysis presented in the remainder of this dissertation.

Rojdi A rests on sterile soil and dates from 2500 to 2200 B.C. It includes two ceramic phases (A1 and A2) and two

architectural phases (subphases 1a and 1b). It is defined by the trash pits in the South Extension (Trench 76N, Strata 7-9) and the floors, hearth, bins, and rock alignments at the base of the Main Mound (Trench 45K, Strata 10-15; and Trench 46L, Strata 10-24). Further, Rojdi A corresponds with the Harappan Urban Phase and with local periods of occupation known as Lothal A, Rangpur II A and B, and Surkotada I.

Rojdi B, resting directly on top of Rojdi A, is best viewed as a transition phase dating to between 2200 and 2000 B.C. It corresponds with the ceramic phase B and the architectural phase 2a. Other than the wall in 45K, Rojdi B is defined by the trash pits in the South Extension (Trench 76N, Stratum 6), and a series of floors and fill in the Main Mound (Trench 46L, Strata 5-9). Culturally, it is associated with the same local and regional periods as Rojdi A.

Rojdi C is the most prominent occupation, and dates from 2000 to 1700 B.C. Corresponding to the ceramic phase C, it includes such architectural features as the large square building on the North Slope, the retaining wall around the site, the large building in the Main Mound (subphase 2b), and all the structures found in the South Extension (phase 1, subphase 2a and 2b). It is defined by the material from trench 76N (Strata 1-5) and from 46L (Strata 3 and 4). Culturally, it corresponds with the Early Post-Urban Phase throughout the region, and locally with Lothal B and Rangpur IIC.

Table 12. Rojdi Carbon-14 Dates.

	5568 Half-Life	5730 Half-Life	Calibrated Date
Old Radiocarbon Dates			
Rojdi Trench B, Period I, Phase B, 1962/63 Season			
TF-200	3810±110 B.P.	1975 B.C.	2415-2135 B.C.
Rojdi Trench C, Period I, Phase B, 1962/63 Season			
TF-199	3590±110 B.P.	1745 B.C.	2160-1850 B.C.
New Radiocarbon Dates			
Rojdi Main Mound (Trench 45K) Middle levels (Rojdi B?) 1962/63 season			
PRL-1088	3770±125 B.P.	1930 B.C.	2420-1980 B.C.
Rojdi Main Mound (Trench 45K) Lower Levels (Rojdi A)			
PRL-1089	3865±115 B.P.	2030 B.C.	2640-2150 B.C.
PRL-1093	3920±105 B.P.	2090 B.C.	2645-2310 B.C.
PRL-1087	4010±105 B.P.	2180 B.C.	2680-2515 B.C.
PRL-1085	4020±105 B.P.	2190 B.C.	2680-2515 B.C.
Average for Lowest Levels: 2469 B.C.			
Rojdi Main Mound (Trench 46L) Middle Levels (Rojdi B)			
PRL-1282	3470±140 B.P.	1620 B.C.	2000-1665 B.C.
PRL-1281	3520±110 B.P.	1680 B.C.	2015-1710 B.C.
Rojdi Main Mound (Trench 46L) Lower Levels (Rojdi A)			
PRL-1285	3740±140 B.P.	1900 B.C.	2410-1945 B.C.
PRL-1284	3810±100 B.P.	1980 B.C.	2415-2135 B.C.
PRL-1283	3980±100 B.P.	2140 B.C.	2660-2385 B.C.
Rojdi South Extension (Trench 76L) Upper Levels (Rojdi C?)			
PRL-1084	3700±145 B.P.	1860 B.C.	2350-1890 B.C.
Rojdi South Extension (Trench 76L) Lower Levels (Rojdi B?)			
PRL-1083	3875±125 B.P.	2040 B.C.	2640-2160 B.C.

Table 13. Rojdi chronology incorporating building levels, dates and preliminary ceramic periods on Main Mound and South Extension.

DATE	NORTH SLOPE	MAIN MOUND	SOUTH EXTENSION
Rojdi D Medieval		46L:1-3 mix 45K:1-6 mix	
Rojdi C 2000-1700	Lg. Sq. Building Retaining Wall	Lg. Building subphase 2b 46L:1-3 mix 46L:4 45K:4-6 mix	All structures subphase 2a,2b 76N:1-5
Rojdi B 2200-2000 Harappan	Fill	Building 45L subphase 2a 46L:5-9 45K:7-9	Trash Pits 76N:6
Rojdi A 2500-2200 Harappan	Fill	Bins 45K Floor 45K Hearth 46L 46L:10-16 (1a) 46L:17-24 (1b) 45K:10-15	Trash Pits 76N:7-9

Rojdi D, the Medieval occupation, consists of the upper strata on the Main Mound. No dates or secure strata can be securely associated with this occupation. Dated by ceramics, it consists mainly of trash pits, and a number of different rock alignments.

A final temporal category used in this study is that of C/D. It consists of the mixed strata in the upper levels of the Main Mound. It is defined by the material in Trench 46L, Strata 1 through 3.

Rojdi and Its Significance.

Rojdi is perhaps best viewed as a permanent settlement, about the size of a town (ca. 7 ha), that was established sometime around 2500 B.C. and was inhabited for about 700 years. These dates imply that Rojdi was an Urban Phase site that survived into the early Post-Urban Phase.

Although the site displays well-planned architectural features and Harappan like artifacts, the material remains exhibited many characteristics. It is thought that Rojdi belongs to one of two kinds of Harappan sites in Gujarat during the third millennium B.C. (Possehl and Herman In Press:33). The Sorath Harappan sites include Rojdi and Rangpur, and the Sindhi Harappan sites are represented by Surkotada and Lothal. Of the three recognized phases of

occupation (A, B, and C) at Rojdi, the first two periods are considered Sorath Harappan, and third, Post-Urban.

Rojdi and the Sorath Harappans are considered regional expressions of the Harappan Urban Phase, stylistically divergent from other Harappan regional populations yet clearly part of the larger Harappan cultural whole. It should not be forgotten that prior to the arrival of the Harappans in Gujarat there was an indigenous hunting and gathering population in the region. After the arrival of the Sorath Harappans in Saurashtra, these hunter and gatherers continued to live in the region and undoubtedly interacted with the newcomers. Rojdi may be an example of a location where indigenous and Harappan populations were interacting.

CHAPTER VI. METHODS

Rojdi was first excavated in 1957-58 by the Gujarat State Department of Archaeology (Indian Archaeology, A Review: 1957-58:18). Subsequent excavations by the same department were in 1958-59 (Indian Archaeology, A Review: 1958-59:19-21), and in 1962-63 (Indian Archaeology: A Review: 1962-63:8). Little information is available in a published format about these excavations or about the material which was recovered from them. The 1982-83 season of excavation, the fourth at Rojdi, was the first by a bi-national team consisting of archaeologists from India (Gujarat State Department of Archaeology) and the United States (University of Pennsylvania). Three subsequent seasons of excavations by this team followed (1983-84, 1984-85, and 1985-86) during which all areas of Rojdi were extensively tested. The data collected during these four seasons of excavations is the basis of the research presented here.

The following discussion will review the methods employed in the four years of excavation under the Direction of Possehl (University of Pennsylvania) and Raval (Gujarat State Department of Archaeology). First, there will be a review of the process of excavation and sampling strategy, then a more detailed description of the collection and analysis of the archaeobotanical data.

Process of Excavation and Sampling Strategy

Since the excavation of Rojdi was intended to answer a series of questions dealing with Harappans in Gujarat, and since the number of digging seasons was limited, a sampling design was implemented which would permit the exposure of the widest variety of habitations, activities and trash areas as possible. This resulted in sampling of the South Extension, Main Mound, North Slope and Gateway areas of the site (figure 14). Using a magnetometer, a geophysical survey of Rojdi was undertaken during the 1982-83 field season. The resistivity survey was hampered by the lack of moisture in the soil, although three strong anomalies were of interest and were eventually explored in trenching.

The site was divided into five meter grids, labelled with number (north-south co-ordinates) and letter (east-west coordinates), and specific grids from each of the four areas of the site were chosen for excavation. Selection was influenced by knowledge of the site, layout of such surface features as walls or rock alignments, results of a geophysical survey, and a desire to sample all areas of the site. Trenches were not selected randomly, nor in any systematic manner, but according to the experience and judgment of the Project Directors. This resulted in trenches being opened on the Main Mound, on the North Area, along the encircling wall and around the Gateway, and in the South

Extension. These trenches ranged from shallow surface clearance of vegetation to nearly three meters in depth.

As soon as walls, rooms or any other feature were uncovered, the unit was dug according to the cultural parameters. Using natural stratigraphy to separate levels, excavation units were dug in 5 cm levels. All soil, except that which was processed for botanical analysis, was screened through 1/4 inch mesh. Afterwards, all artifacts were preliminarily sorted by grid and strata number, and grouped into categories such as lithics, bone, and small finds. Material from each of these categories is presently being analyzed by specialists.

Each grid or trench was usually excavated under the direction of a single supervisor (Indian or American), although sometimes the responsibility was assumed jointly. The crew of laborers, usually from the nearby village of Shrinathgadh, ranged from seven to twelve persons per trench. After four seasons of excavation, a large variety of laborers and supervisors had taken part in digging, whose different methods of working may have inadvertently contributed to the variability seen in the recovered material. However, this is not thought to be a significant problem for the interpretation of remains from the site. The author excavated slightly over 20 percent of the deposits that were analyzed. He was responsible for nearly 60 percent of the floating, over 90 percent of the sorting and all of the plant

identifications. The excavation of 46L, and the analysis of its plant remains, were performed entirely by the writer.

Lot forms were filled out for each excavated unit. Based on grid units or features, and in strata of specified depths, each lot number remained associated with all artifacts associated with that excavation unit. Data from each lot form was eventually entered into the computer so that information regarding trenches, strata, depth, soil, features, artifacts, dates and names of excavators is immediately available.

Collection and Analysis of the Archaeobotanical Material

A systematic sampling and intensive recovery program was developed for the botanical remains at Rojdi. Sediment samples were collected from each stratum within every trench, from the fill of all features, pits, hearths, burials, and ceramic vessels, from the surface of artifacts, floors, and activity areas, and from all trash dumps. Besides taking samples during the process of excavation, three complete soil columns were collected at the end of the project. For comparative purposes, these columns were taken from the deep trench on the Main Mound and in the deepest portion in the South Extension. The initial sampling strategy was developed and carried out by Gail Wagner, who worked on the Rojdi

project as an archaeobotanist during the first two field seasons (1982-83 and 1983-84) (Wagner 1985).

In all nearly 500 samples, from over 2400 liters of soil, were processed and analyzed. Samples were collected from a variety of archaeological contexts (figure 18), from each region of the site (figure 19) and representing each period of occupation (figure 20). Sixty of the samples were analyzed for their pollen, while the remaining samples were floated for their larger macrobotanical remains.

Figure 18. Types and percentages of samples collected according to period of occupation.

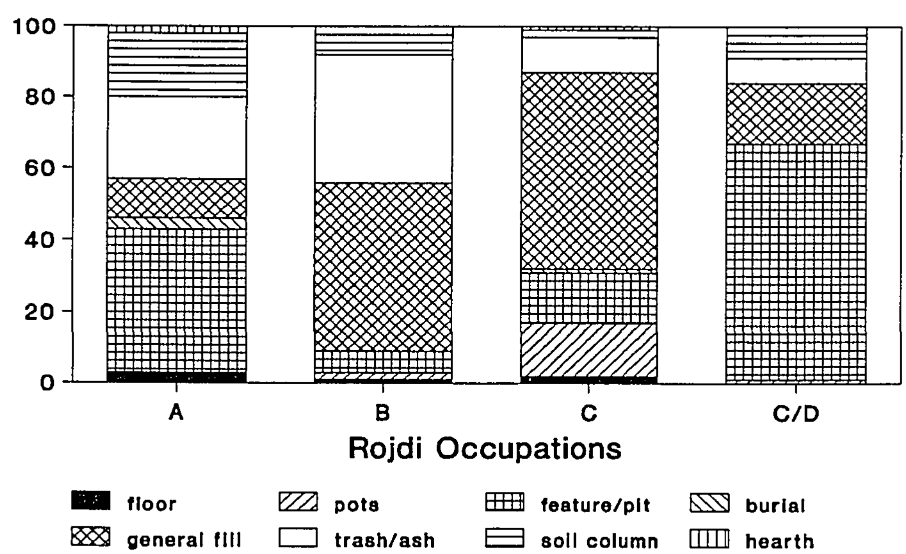


Figure 19. Percentage of archaeobotanical remains by site region.

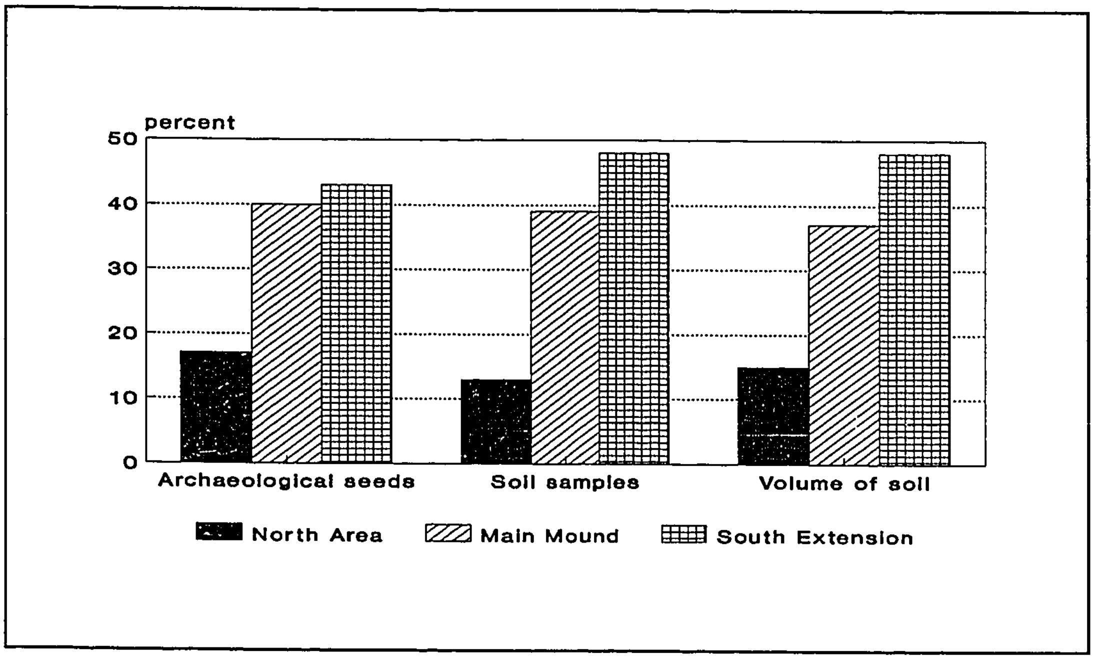
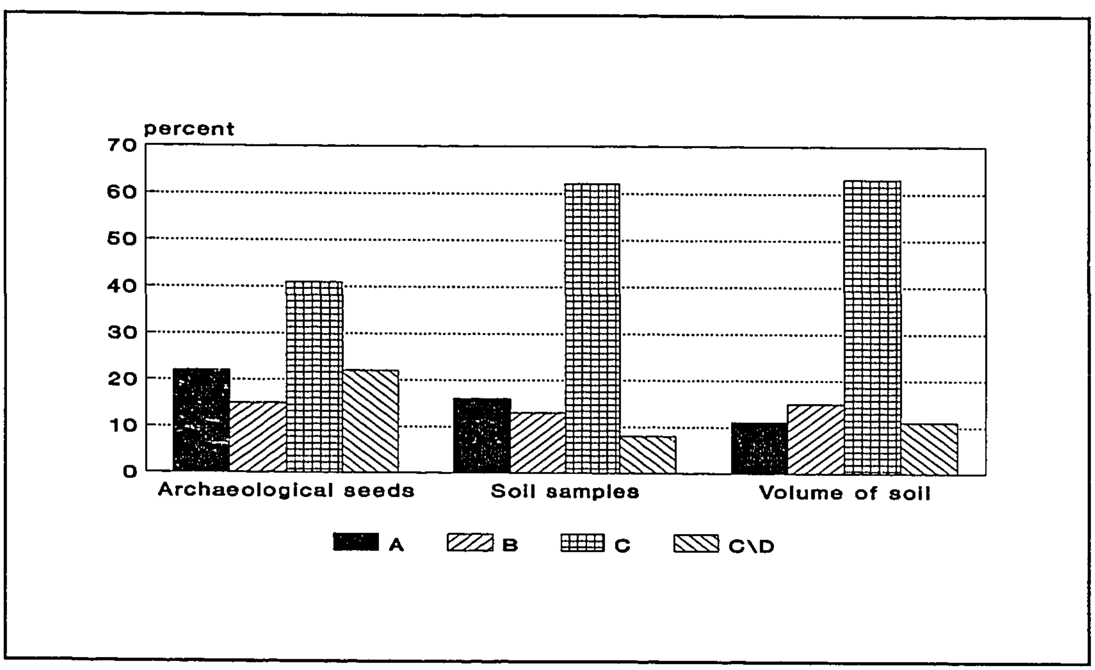


Figure 20. Percentage of archaeobotanical remains by time period.



The majority of the archaeobotanical reconstruction is based on the material recovered from the flotation samples. Plant impressions in pottery and burned clay were also analyzed, although they represent a minor portion of the plant data. Charcoal was recovered throughout Rojdi and its provenience recorded, but like the pollen, analysis is still in progress. Plant opal phytoliths were also successfully recovered from the Rojdi soils, but due to the lack of the necessary comparative material, and the richness of the other types of botanical data, they were not analyzed at the time of writing. The pollen, charcoal and phytolith material from Rojdi is still being examined and will be written up at a future date.

Due to the success of the flotation system, and the large and varied data base it produced, the focus of this work is upon seeds and seed parts. The flotation system used a modified SMAP machine (Wagner 1983). It consisted of a modified oil drum provided with running water and a "basket" insert with a screen bottom. The barrel was filled with water and soil samples poured into the basket. The earth and water mixture was agitated by hand and by a water-pipe jet coming up through the basket screen from within the barrel. Silt settled through this screen to the bottom of the barrel. A "heavy fraction" of stones sherds, small finds, and other materials larger than 1.5 mm collected on the basket screen. "Light fractions," including most plant

remains floated off of the top of the basket into cheese cloth where they were tagged and allowed to dry along with the heavy fractions. After drying, the heavy fraction was sorted by sifting the material through geological sieves and picked through by hand. Plant remains from the heavy fraction were included with corresponding light fraction for further analysis.

The dried light fraction, consisting of archaeobotanical remains, small bones and bone fragments, shell, rootlets, stone debitage, charcoal, and the occasional bead, were examined under a microscope. Plant parts (e.g. seeds, husks, woody material) were then separated out and placed in labelled gelatin capsules for further analysis.

In an effort to test the flotation recovery rate for seeds in the soil, a poppy seed test (Wagner 1982:127-132) was employed. The test consisted of placing fifty carbonized poppy seeds (Papaver somniferum) in the archaeological soil of some of the samples prior to flotation. When the light fraction of these samples were examined under the microscope the number of poppy seeds counted would give an indication of the recovery rate accuracy. The tests, run in all four seasons of excavation, had rates of recovery of between 82 percent and 98 percent. These rates compare well with tests performed on other projects using different types of flotation equipment (Possehl et al. 1985:98). This process also helps in making quantative comparisons of

archaeobotanical remains recovered from different sites where different flotation systems were used (Crabtree 1982:95).

Efforts were made to keep the volume of soil at a standard seven liters, although this could not always be maintained since smaller amounts of soil were collected from areas such as the interior of pots and various features. The volume of soil in each sample was recorded, as was the volume and weight of each corresponding light and heavy fraction. Any information (particularly concerning contamination) that is relevant to the understanding of the significance of the material's occurrence was noted as well.

The identification of the botanical material was based on a comparative collection consisting of both carbonized and uncarbonized seeds from plants growing throughout Gujarat. Since a comparative collection was not available prior to this project, it became necessary to build one. A seed collection was put together, consisting of nearly one thousand different species, from a combination of sources (e.g. Musil 1963). Plants found growing in the area around Rojdi were collected, identified and pressed. Seeds from these plants were placed in vials, some were deliberately carbonized for more accurate comparisons to the archaeological material. The bulk of the comparative collection was obtained by taking samples from pressed plants in herbaria. These seeds were also placed in vials with the specimen name, herbarium name and specimen number. A large

part of the preparation of this collection was undertaken of Dr. Vishnu-Mittre, who is in the process of compiling a seed catalogue based on this material. Identification of the Rojdi archaeobotanical material was also aided by a number of different scholars and by comparison with archaeological seed collections from other sites. 85 percent of the Rojdi material was identified to at least the genus level.

All botanical data was organized for entering into an automated data retrieval system. The standardized recording of all botanical remains helped elicit the maximum amount of patterned variability, and facilitates the comparison, contrasting, and analyzing of different kinds of botanical data from different proveniences so as to reflect the biological nature of the plant material and the behavioral variability of the human uses of the plants (Field 1977). The computer system used here was designed for flexibility and thorough coverage of a wide range of information and can be expanded and updated at anytime, making it an open-ended system. It was expanded to include botanical remains from archaeological sites throughout South Asia. It presently includes all published data presently available for South Asian sites which date to before 1000 B.C.

Of the range of variables which aid in the analysis of botanical data and which are adaptable to a computer retrieval system, the following were selected for use in this study: the name of the identified species; its provenience,

which includes the site name, geographic region, trench number, lot number, depth and stratum; the type of botanical material being identified and the accuracy of the identification; the time period, cultural phase and corresponding date of the material being described; a description of the material which includes its state of carbonization, its completeness, measurements and other identifiable features; the volumes and weights of the corresponding heavy and light fractions; associated samples and features plus a description of where the sample was collected. Other information recorded includes the names of the excavators, identifiers and analysts of the material as well as the corresponding dates of when this work was performed.

All data from these forms were placed in a format designed to work using Q & A software (produced by Symantec Corporation) on an IBM personal computer system. Other important information about Rojdi was also placed in an IBM based system utilizing Q & A. This enabled analysts of Rojdi material to easily reference and retrieve Rojdi data, and to make quantitative comparisons or find statistical relationships between all types of Rojdi data, including information found on lot forms, ceramics and small finds. All entered numbers refer to counts of whole seeds, unless stated otherwise. Fragments were counted as such (e.g. 1/2

being counted as 1/2), so that tabulated totals actually reflect their proportional representation.

Understanding the spatial and temporal distributions of the archaeobotanical remains is fundamental if we wish to comprehend the role and importance of this material within the Rojdi assemblage (Asch and Sidell 1989). Further, quantitative methods help in the understanding of site formation processes and prehistoric uses of plants (Miller 1988:1, 1989). A number of different quantitive methods and measures were applied to the Rojdi archaeobotanical data. These include density, percentage or proportion, purity, and ubiquity. While these methods measure different aspects of archaeobotanical variability, their advantages and disadvantages counterbalance each another, so that together they contribute to a stronger and possibly more coherent paleoethnobotanical reconstruction (Sullivan 1987:145; Toll 1989).

All four efforts at quantification involve the use of ratios, or statistics that provide a simple means for standardizing data by comparing two values by division. A ratio consists of a numerator and a denominator and requires a measurable quantity of the material appearing as the denominator. The variables chosen are relevant to the questions being asked and allow for intersite and intrasite comparisons. The use of ratios allows the comparison of samples of different size, the measurement of variation due

to deposition or preservation, and the comparison of material from different proveniences which nevertheless share attributes that make comparison possible (for example, seeds that are of the same species) (Miller 1988:1).

Density is generally used as a basic measure for understanding depositional and preservational variability. The denominator usually represents the total volume of the sediment in a sample while the numerator represent the number of items or weight of material being analyzed from the sample. It is one of the most basic ratios used today by paleoethnobotanists (Miller 1988:2). It is based on the assumption that if everything is equal the larger the volume of sediment the more plant remains will be extracted. Therefore, the higher the density, the more intense the activity involving that type of plant. Making generalizations on the basis of density calculations performed on limited samples may be unwise, unless all the variables dealing with plant deposition, preservation and collection are carefully considered. For example, while at first sight the density of charred remains in an archaeological site may suggest the intensity of occupations at that site, further investigation may show that this ratio in reality reflects the intensity of activities involving fire (Pearsall 1983:129).

Percentage or proportion refers to the relative abundance of a specific taxa in a given assemblage.

Percentage is best regarded as proportion times 100, and where the numerator is often a subset of the denominator. It is often used as a gauge of prehistoric floral importance (Miksicek 1983, Sullivan 1987), to compare different preservation contexts, or as a method to standardize different amounts of material per sample, or to detect replacement of one category of material by another (Miller 1988:4,5). If preservation of archaeobotanical remains requires some form of accident involving carbonization, then percentage may indicate the magnitude of past accidents (Minnis 1978, 1986:209). Consequently, a small number of spills seriously biases the representation of individual taxa (Sullivan 1987:145; Adams 1980:9). Percentage calculations are in general insensitive to the spatial distribution of certain remains. Furthermore, the percentage of one type only makes sense in relation to the percentage composition of the rest of the assemblage (Sullivan 1987). Thus, it is important to consider not only what causes the percentage of plant remains of one type, but also the causes of percentages of others.

Purity, the third method of quantification, represents the proportion of a specific taxon within a single sample. Purity helps determine the occurrence and location of various activities. For example, the purity of crop remains can be indicative of the efficiency of processes designed to clean

the crop after harvest or the willingness to allow weeds to grow in the fields (Dennell 1972:150).

Ubiquity is the percentage of samples from a given assemblage which contains a specific taxon. It may also measure the number of accidents of carbonization that occurred, which may itself be indicative of usage patterns, and how widespread they may have been (Minnis 1986:210). While this technique controls for spatial variation, it exaggerates the importance of uncommon plant types, since a single seed or several hundred seeds are equally represented (Sullivan 1987:145; Minnis 1980:380).

As will become apparent when the significance of the Rojdi botanical data is discussed, numerical methods help in identifying the spatial and temporal patterning of the data base. Ratios calculated on different samples from different contexts assist in the identification of different activities in the site (Dennell 1972:150, 1974), and therefore, every type of feature which may have been associated with different activities was sampled (see figure 18). Yet, since samples from different contexts (for example, storage jars, floors, hearths, middens or trash pits, general fill) do represent different activities, caution is needed when deciding which samples to compare. Therefore, the context of each sample will be considered during all stages of analysis. Similarly, the condition and type of plant part being analyzed need to be taken into account. Ordinarily, carbonized remains should

only be compared with carbonized remains, and seeds should only be compared with seeds. Unless otherwise stated, these conventions will be observed throughout the analysis.

An important task in any archaeobotanical analysis is to assess the extent and significance of modern contamination. Contamination refers here to all plant finds at Rojdi which have been extracted from the soil yet are not thought to have been deposited in the soil at the time of occupation. Contamination can occur as a result of natural movements in the soil such as settling, or from the burrowing of animals or insects, or even human action.

Since plant remains can move around in the soil matrix it is important to be certain that a carbonized seed represents the time period it is associated with (Gasser 1985; Gifford 1981). The only sure way to do this is to date each seed itself. With the use of radiocarbon dating by accelerator mass spectrometry it is now possible to date vegetable remains the size of an individual seed (Harris 1987). Up to the present, the Rojdi botanical material has not been dated using this new technique, although there are plans to test selected material in future in order to verify some assumptions. Presently, the value of the botanical data base is based on careful excavation, reliable techniques of extraction and analysis and on the assumption that certain quantitative methods of analysis will isolate untoward biases in the data. In large data bases like those from Rojdi,

small amounts of unrecognized contaminants should not greatly affect the end results.

CHAPTER VII. DESCRIPTION AND IMPLICATIONS OF PLANT MATERIAL

The macrobotanical material recovered and identified from the Rojdi excavation totals 14,389 individual plant remains (table 14). The majority of the material was seeds or seed parts, of which 86 percent was identifiable to at least the genus level. The macro-botanical material was obtained from 455 samples of soil totalling 2469 liters (table 15). Since only 71 samples contained no seeds, the average number of seeds per liter soil was nearly six. The average sample at Rojdi consisted of 5.4 liters of soil and contained 32 seeds. While all the botanical material from each soil sample was analyzed, over half was unidentifable, from insecure archaeological proveniences, or represented recent contamination (figure 21). While only identifiable, archaeologically secure material is of use in the reconstruction of Rojdi subsistence, the remainder has value for understanding site formation and taphonomic processes, or for future paleoethnobotanical reconstruction at Rojdi when we know more about the relationship of strata with occupations, and are able to identify some of the fragmented seeds.

Table 14. Rojdi botanical counts and identifications by period of occupation.

TAXA	A	B	C	C/D	TOTAL
Abelmoschus	0	4	7	4	15
Acacia	0	0	0	2	2
Blainvillea	0	0	0	1	1
Boerhavia	0	0	35	0	35
Borreria	2	0	17	3	22
Brassica	0	1	1	0	2
Carex	0	0	261	9	270
Cenchrus	0	0	40	0	40
Cheno-Ams	4	4	28	46	82
Chenopodium	59	556	75	85	775
Chloris	0	5	281	15	301
Convolvulus	0	0	2	1	3
Corchorus	0	17	11	59	87
Cucumis	0	0	4	1	5
Cymbopogon	0	0	0	1	1
Cyperus	2	3	31	2	38
Dactyloct.	8	11	274	36	329
Desmodium	36	0	0	0	36
Digera	3	8	775	16	802
Digitaria	0	0	56	13	69
Echinochloa	0	0	12	0	12
Eleusine	1083	98	95	50	1326
Elyonurus	0	0	17	0	17
Euphorbia	7	349	592	175	1123
Ficus	10	3	42	12	67
Fimbristylis	0	4	12	8	24
Glossocardia	0	14	0	0	14
Goniogyna	0	0	61	0	61
Hordeum	10	0	0	3	13
Impatiens	0	0	6	0	6
Indigofera	7	4	165	3	179
Ipomoea	0	0	2	2	4
Lathryus	0	0	2	84	86
Lens	0	0	3	0	3
Linum	0	0	1	2	3
Lotus	0	1	0	7	8
Medicago	0	0	0	20	20
Melilotus	4	3	13	11	31
Melochia	0	0	5	1	6
Neptunia	0	0	4	2	6
Panicum	230	266	166	357	1019
Phyllanthus	0	3	70	1	74
Paspalum	0	0	4	3	7
Peltophorum	0	0	10	0	10
Pisum	0	0	0	0	6

Table 14 (continued).

TAXA	A	B	C	C/D	TOTAL
Polygola	0	0	1	0	1
Polygonum	0	0	6	0	6
Rorippa	0	0	4	0	4
Saccharum	0	3	299	12	314
Sapindus	0	0	1	0	1
Scirpus	0	1	1	2	4
Setaria	28	22	1489	157	1696
Sida	1	0	0	0	1
Solanum	0	3	49	13	65
Sorghum	0	0	24	89	113
Stellaria	0	0	9	0	9
Tragus	0	2	143	11	156
Trianthema	21	62	2009	637	2729
Verbascum	0	0	30	5	35
Vicia	0	0	1	1	2
Vigna	1	0	2	51	54
Zizyphus	78	2	0	2	82
Unknown	148	289	952	688	2077
TOTAL...................14,389					

Figure 21. Percent of archaeobotanical material from each Rojdi occupation that is archaeologically secure (based on provenience and carbonization).

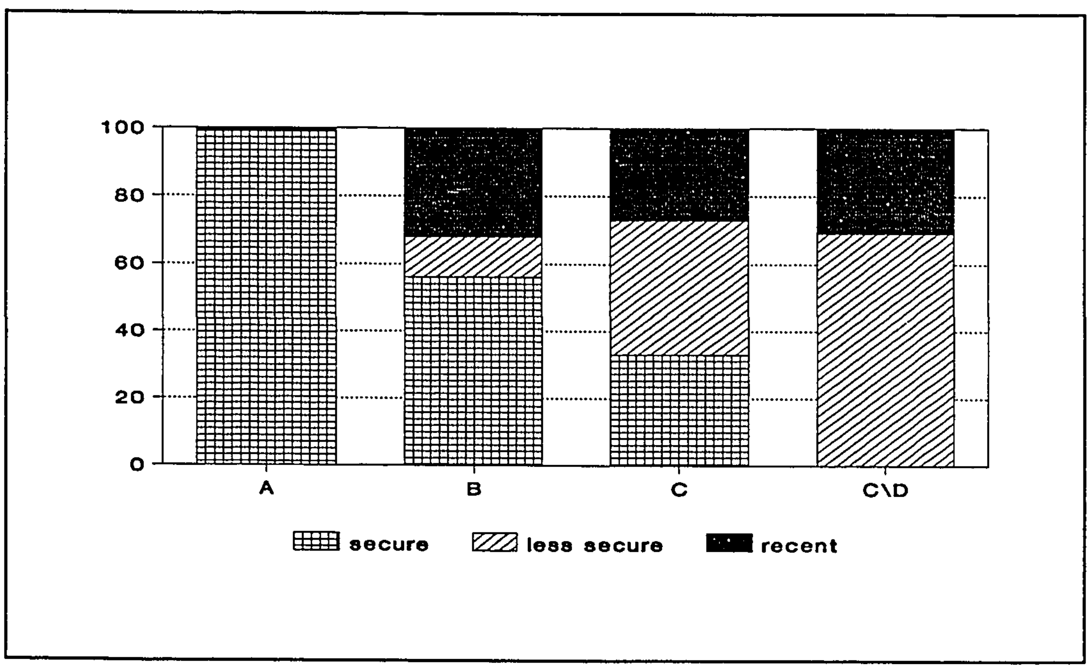


Table 15. Rojdi botanical remains, their counts and distribution.

	REGION				OCCUPATION			
	Rojdi Total	North Slope	Main Mound	South Ext.	A	B	C	C/D
Total Material	14,389	2521	5730	6138	1742	1724	8214	2709
Secure Arch. Mat.	8,010	711	4197	3102	1740	1182	3334	1754
Poss. Recent	6,379	1810	1533	3036	2	542	4880	955
No. of Diff.	84	43	65	62	22	31	59	57
Total Soil-liters	2469	365	910	1194	280	374	1559	258
Secure Arch. Soil	1433	-	549	884	280	195	958	-
Avg. Seed/Liter (for all seeds)	5.8	6.9	6.3	5.1	6.2	4.6	5.3	10.5
Avg. Seed/Liter (arch. seeds only)	3.2	1.9	4.6	2.6	6.2	3.2	2.1	6.8
Avg. Liters of Soil/Sample	5.4	6.2	5.1	5.5	3.8	6.5	5.5	6.8
No. of Samples	455	59	178	218	74	59	284	38
Secure Arch. Sample	284	-	119	165	74	31	179	-
Avg. Seeds/Sample	32	43	32	28	23	29	29	71
Avg. Arch. Seeds/Sample	18	12	23	14	23	20	12	46
Samples with no Seeds (number)	71	7	14	50	13	6	48	4
Samples with no Seeds (percent)	16	12	8	23	17	10	17	10

Using morphological, ecological, and economic information about the plant taxa, in association with their numerical distribution within Rojdi, paleoethnobotanical reconstruction becomes possible. In this chapter, the description and distributional information about the Rojdi seeds is presented. Each taxon is discussed in alphabetical order rather than by family, so that archaeologists unfamiliar with the Linnaean system will readily be able to look up material discussed in this text. The description includes the family, number of seeds, their condition, the reliability of the identification, the location in which they were recovered, their morphological description, including measurements where available, types of habitats in which they are commonly found, their common or ethnographic uses, whether human management was necessary or likely, whether they were domesticated and how this could be determined, and finally, how they may have entered the archaeological record.

Some of this information will be based on the following sources: Bombay Presidency 1889, 1884a, 1884b, 1886; Hooker 1872; Kirtikar and Basu 1918; Kumar et al. 1963; Chalam and Venkateswarlu 1965; Government of India 1908, 1948, 1950, 1952, 1956, 1959, 1962, 1964, 1965, 1966, 1969, 1972, 1976a, 1976b; Government of Gujarat 1961, 1962, 1965, 1969, 1970, 1977, 1979, 1980, 1982; Shah 1978; Randhawa 1980; Jain 1981; Church 1983; Chanchala 1984; Bharaucha 1983; Blanford 1891; 1876; Burkil 1953, 1965; Champion 1935; Champion and Seth

1968; Chandola 1959; Kurup 1979; Learmouth 1964; Legris 1963; Nayar 1958; Patel 1977; Puri 1960; Saxena 1979 1981; Stewart 1982; Whyte 1964). Unless a specific description was obtained from only one of these works, the following discussion will not include individual citations.

The depth of discussion about each taxa will depend on its significance to the arguments presented in this work. Therefore, taxa occurring due to recent contamination will be mentioned briefly, while plants which are part of the prehistoric occupation will be discussed in more detail.

Abelmoschus. (Malvaceae). Fifteen seeds, mostly whole, have been tentatively identified as belonging to the genus Abelmoschus. The seeds are black, slightly striate, and globose. They appear in an unburned or uncarbonized state from the upper levels of the main mound and South Extension areas of Rojdi, and therefore, most likely represent recent contamination. Some plants of this genus (known locally as Bhindi) are cultivated today in India, including regions of Saurashtra. Ethnographically, there are only records of seeds of these plants being used for medicinal purposes. Most species of Abelmoschus growing in India today are found throughout the year, though most commonly during the monsoon, and generally in hot environments.

Acacia. (Mimosoideae). Only two carbonized seeds of Acacia sp. have been recovered. Both are from the Main Mound and are part of the material classified as C/D, or the mixed Rojdi C and Early Historic occupations. Acacia wood is a common fuel today and charcoal from Rojdi C has been tentatively identified as belonging to this genus. After the charcoals from the rest of the site have been analyzed, Acacia will probably be represented in all areas of the site and during all occupations.

There are over 22 species of Acacia which are indigenous to India. Most of these are thorny trees or shrubs growing in dry and arid regions. Acacia is a common genus in Saurashtra and can be seen growing on Rojdi today. The common names for the varieties found growing in Gujarat today include babul, cutch tree, siver wattle, green wattle, black wattle, Australian blackwood, and umbrella thorn. While tannin, gum and timber are its most common derivatives, the pods and leaves of some species are regularly used as fodder, especially for sheep and goat. All species of Acacia are used for fuel and often grown near villages for this purpose.

Blainvillea. (Compositae). Only one seed, tentatively identified as B. acmella (known locally as dholu or fuldu), was recovered from Rojdi. Also known as Verbesina or crownbeard, it was unburned and recovered from near the surface in a grid along the North Slope area of the site.

It is very common in the region today and probably represents recent contamination.

Boerhavia. (Nyctaginaceae). Thirty-nine seeds or fruit parts belonging to B. diffusa (hog-weed) have been positively identified from the Rojdi soil matrix. They were recovered from the surface levels of all regions of the site, in an unburned condition. These seeds, representing recent contamination, are common and abundant throughout Gujarat today. It is a perennial creeping weed with some medicinal value, although it has no record of cultivation.

Borreria. (Compositae). Of the four species of Borreria (Ganthiyu, Kharsat Shankhlo) occurring in India today, two are common to Gujarat, B. hispida and B. stricta. One or both of these species are represented in the Rojdi record where 22 seeds belonging to this genus were recovered. The seeds were 1.5 mm to 2.8 mm long, ellipsoid/oblong, and ventrally grooved. Found in all areas of the site, the seeds were generally charred or well burned. In an unburned state they would appear reddish-brown. They were recovered in the upper as well as the deepest levels of the site, including the lower strata of the Main Mound (Trench 46L). Only Rojdi B strata lacked Borreria seeds. Both species are common throughout the year in Saurashtra, and can be found flowering from July to January. This tropical herb has several

medicinal applications as well as its seeds being used as a substitute for coffee and its leaves being eaten in times of scarcity.

Brassica. (Cruciferae). Only two seeds belonging to the genus *Brassica* (mustard) were recovered at Rojdi. One was burned, fragmented and from half way down the Main Mound, with only a probable identification. The other was whole and only partially burned, positively identified and near the surface in the South Extension. Both seeds appeared rounded (approximately 2 mm in diameter) and minutely pitted. Of over 150 species of this genus, a number are common to Gujarat, including *B. campestris* (Brown Sarson) and *B. juncia* (Rai). These annual and biennial herbs are most common in northern temperate zones but are found in the tropics and sub-tropics, often as cold weather crops. While north-western India is thought to be one of the centers of origin of *B. compestris*, China is the likely origin of *B. juncia.* The whole seed may be *B. campestris*, which is very common in Gujarat today, both as a cultivated plant and as a weed. As an oil seed crop, *B. compestris* is harvested in the winter along with other cereals like wheat and barley, and grows best in medium or heavy loam soils. These oil yielding seeds are extensively cultivated in India for the production of mustard oil, commonly used in cooking.

Carex. (Cyperaceae). Remains of 270 achenes or seed fragments belonging to Carex sp. (sedge) have been recovered from the surface levels in all three regions of Rojdi. The remains are unburned and appear recent. The achenes average 2.50 mm long, 1.18 mm wide, and have between 6 - 8 longitudinal ribs. This perennial sedge commonly occurs in temperate regions. The material is only tentatively identified since comparable material is lacking.

Cenchrus. (Poaceae or Gramineae). Of the 40 remains of Cenchrus (Anjan hay) found at Rojdi, all but 10 were recovered in South Extension grids. All of the seeds and plant parts representing this genus were unburned and from the surface samples implying recent contamination. Cenchrus sp. are very common and often troublesome weeds found throughout Gujarat as well as growing on the surface of Rojdi.

Cheno-Ams. (Amaranthaceae and Chenopodiaceae). Seeds of this category represent one of two families: Chenopodiaceae and Amaranthaceae, or the genera Chenopodium (goose foot) and Amaranthus (pigweed). Although in some regions it is possible to distinguish seeds or pollen specimens of these two genera, in South Asia this remains a difficult task. Therefore, a grouping labeled Cheno-Ams is used in this text.

Eighty-two seeds from all areas of Rojdi were recovered. The seeds were black or carbonized, orbicular, glabrous with generally smooth surfaces and ranging in diameter from nearly one millimeter to slightly over two millimeters. Cheno-Am seeds were mostly burned and in general recovered in small amounts from any one sample. They were fairly evenly distributed throughout Rojdi and found at most depths. While both Chenopodium and Amaranthus seeds may be represented, the carbonized seeds with archaeological significance are probably Chenopodium since Amaranthus is not thought to be indigenous to South Asia. No archaeological finds of Amaranthus date to before 2000 B.C.

Species of both these genera are very common in Gujarat today as weeds and as cultivated plants (generally in small gardens). These annual or perennial herbs or shrubs have many well documented uses, including the consumption of their greens and seeds, and for medicinal purposes. All 25 species of Amaranthus and eight species of Chenopodium which grow in India today are commonly found growing in disturbed conditions found along roads and dissected floodplains. Ideal habitats for their growth are agricultural fields and trash heaps.

Of the 82 seeds of Cheno-Ams recovered from Rojdi, only 35 are burned or carbonized. These come from lower strata, and are unlikely to represent recent contamination.

Chenopodium. (Chenopodiaceae). The only seed type from the Cheno-Ams category which could be positively identified to the species level is Chenopodium album (Lamb's Quarters). Seven hundred and seventy-five seeds were collected from Rojdi which could be identified as C. album. The seeds are very distinct, orbicular, glabrous, compressed with an acute margin, with a smooth and shiny surface and a completely annular embryo. Their average diameter is 1.13 mm to 1.62 mm depending on carbonization.

It is an important seed in the Rojdi record, representing nearly five percent of the total seed record and a ubiquity rate of 18 percent. The seeds appeared in a charred and burned state as well as unburned. When unburned, they ranged in color from white, black and brown. The greatest density of C. album seeds came from stratum 9 in 46L, where 66 percent of all C. album, or 476 grains were recovered, and many more were observed. The density of C. album seeds per liter of soil was nearly 12 in Stratum 9, while on either side of this level, it averaged less than one seed per liter of soil. The only other area where this high density occurred was in the lowest levels of 76H, on the South Extension. In those samples where the C. album density and counts were high, few other seed taxa were represented. C. album, like most species of Chenopodium, is a prolific seed producer where one compact plant head can produce hundreds if not thousands of seeds. This species can be

found throughout Gujarat, in the wild and as a common weed in cultivated fields. It grows well in a variety of environments and elevations. In India, it flowers from late fall to early winter, and is harvested from January to April.

Chenopodium has many different uses after being collected from wild or cultivated fields. Besides medicinal uses, the young shoots of the plant are eaten as greens and the seeds are often boiled and eaten as a substitute for cereal grains. Seeds of C. album are also commonly mixed with grains such as rice to make it more palatable, or with Eleusine coracana and Zea mays to make a fermented drink.

Chloris. (Poaceae or Gramineae). A common plant contaminant found throughout the surface strata of Rojdi was Chloris sp. (Rhodes grass or gandi). Three hundred and one seeds or plant fragments were recovered, and all but 38 were from the upper 50 cms of soil. Remains of this plant were well scattered throughout the soil matrix in 102 different samples. It was most abundant in the surface samples from the South Extension. No burned or carbonized remains of Chloris were observed. This perennial is common throughout Saurashtra and is seen on the surface of Rojdi. It flowers from August to January.

Convolvulus. (Convolvulaceae). Three carbonized seeds belonging to the genus Convolvulus (Morning Glory) were

recovered from two different trenches on the Main Mound (42L and 45K). The identification is preliminary due to the poor state of preservation of the remains. They are glabrous and subtregenous, and were recovered from two samples located at about 1.4 meters below the surface. A number of different species belonging to this genus occur today in Saurashtra. While generally considered a herb or undershrub which grows well in temperate environments, some species do grow well in the tropics.

Some species are used as a purgative, others are considered useful as fodder or for their medicinal properties. There is also some reference to the fleshy peduncles and unripe seed vessels being eaten as a vegetable.

Corchorus. (Sterculiaceae). A total of 87 Corchorus sp. (jute) seeds were recovered from the mid and upper levels of Rojdi. Because the seeds are small and in a natural state are black, at times it was difficult to determine if they were carbonized. Nearly 60 percent appear to be in an uncarbonized state. Due to the lack of comparative material, these wedge shaped (cuneate), angular, smooth, glabrous, seeds were difficult to determine to species, although it is believed that they represent Corchorus sp. The majority of the seeds were from the Main Mound (45K and 46L), only two were recovered from the South Extension (76H and 76K) and nine from the North Slope area (21U). While seeds of

Corchorus sp. were recovered in levels which represent Rojdi B and C occupations, it is possible that most if not all seeds of this taxa are present due to recent contamination. Only 19 grains are carbonized and from proveniences which are archaeologically secure.

Of the 40 or so species of Corchorus which can be found throughout the tropics, eight occur in India. All eight have been reported in Gujarat. Two species (C. capsularis and C. alitorius) are used in commercial jute cultivation, for making coarse woven fabrics. While the remaining species are mainly used for their fiber, the genus has been used medicinally. There are also reports of Corchorus sp. being grown as a pot herb for food.

Cucumis. (Cucurbitaceae). Of the five seeds of Cucumis (sweet melo, cucumber) recovered from Rojdi, three are unburned and come from the surface levels. These three seeds are glabrous, pale-brown and ellipsoidal, and are very similar to seeds of C. prophetarum, a common herb found throughout Saurashtra. Further, they probably represent recent contamination. The remaining two Cucumis sp. seeds are more difficult to identify to species due to their carbonized and decaying state. They appear to represent two different species, although at this time it is difficult to determine which. Six different species commonly occur in Gujarat today. One of these burned seeds is from the upper

levels of 21U in the North Slope area, while the other is from the upper levels of 45K on the Main Mound.

The burned seeds may represent wild or cultivated species since *Cucumis* fruits are commonly grown and eaten in Saurashtra. *Cucumis* grows well in hot dry regions yet requires lots of water. They are often grown in sandy river beds, often after the monsoon has come. *Cucumis* also has a number of medicinal applications.

Cymbopogon. (Poaceae or Gramineae). One large charred seed belonging to the genus *Cymbopogon* was recovered from the Main Mound area of Rojdi belonging to C/D strata. Based on comparative material it appears that the seeds belongs to the species *C. martini* (rosha grass). The seed of this grass is oblong, subterete to plano-convex in cross-section. It can be found growing in Saurashtra and throughout Gujarat, although it is not commonly found. While this grass does have some medicinal properties, it is cultivated for its oil, in which case it is harvested in the fall, often in November.

Cyperus. (Cyperaceae). Thirty eight carbonized seeds of *Cyperus* (flat-sedge) were recovered from the Rojdi deposits. Most of the over 60 species which occur in India can be found in Gujarat. Based on comparisons to modern species of *Cyperus*, two taxa match up well with the Rojdi samples, *C. articulatus* (Guinea rush) and *C. rotundus* (nut grass). At

this point it is unsure which species actually occurs at this site. The seeds range in size from 1.12 mm to 1.43 mm in length, 0.42 mm to 0.86 mm in width. They are triquetrous, oblong or obate oblong and microscopically punctate.

Eleven seeds were from the North Slope (27S) and 11 were from the Main Mound area (45K, 46L, 46K), the remaining 16 were from the South Extension (74H, 75H, 75I, 75J, 75N, 76H, 76K, 76L, 76M, 77L and 78H). While seeds were recovered from the lowest depths of Rojdi, only eight were recovered from the surface levels (stratum 1 or 2). Two seeds are associated with Rojdi A. Three are associated with Rojdi B strata, 31 with Rojdi C and the remaining nine seeds with Rojdi C/D.

Both Cyperus sp. are common in Saurashtra today, especially in moist ground. While generally not cultivated in this region they are used for fodder and for matting. They also serve medicinal and perfuming purposes, besides the tuberous rhizomes being eaten in times of scarcity.

Dactyloctenium. (Poaceae or Gramineae). Three hundred and twenty-nine seeds from all areas of Rojdi compare well with those in the comparative collection labeled Dactyloctinium aegyptium. D. aegyptium has in the past been referred to as Eleusine aegyptium or known locally as makra. While 168 were unburned, nearly half showed at least some signs of carbonization. Seeds belonging to D. aegyptium are quite

distinct due to their rectangular, very rugose appearance. When unburned they have a reddish color. They averaged 0.5mm to 1mm in length and width by around 0.3 mm to 0.1 mm in thickness.

D. aegyptium seeds were recovered from 92 different soil samples, nearly 20 percent of all those collected and sorted. Only 54 seeds were from the Main Mound area, and 95 from the South Extension portion of Rojdi, while the remaining were from the North Slope. Those from the Main Mound and South Extension were almost all carbonized, with the majority coming from the top three strata, although a few grains were recovered from the lowest levels.

This grass is an annual, common throughout Gujarat. Besides being found throughout the plains of India, it can be found growing on poor dry soils and as a weed in open areas and cultivated fields. While its value as a fodder is not great, it is often used as such. Today, seeds of *D. aegyptium* are eaten during famines and times of scarcity. The grains are either cooked into a porridge or ground into a flour and made into cakes. Although seeds of this grass are thought to cause internal disorders they are also used medicinally.

Desmodium. (Papilionaceae). While only 36 seeds were recovered belonging to this large genus of perennial or annual herbs or shrubs (tick-clover), their provenience makes

them an interesting and possibly important plant taxa. All the seeds were in a mineralized state found in the bottom of trench 45K, near some circular features referred to as "bins" by the excavators. It is possible that the occurrence of the seeds may help explain the function of these features. Because of the condition of these seeds they are difficult to identify to species. They measure 2.83 mm to 2.52 mm in length, smooth, glabrous and are whitish in color. No seeds like this were recovered at any other location in Rojdi. All the seeds were from just two samples, from 247 cms below the modern surface.

Over 12 species of Desmodium can be found today in Gujarat. They grow well on black cotton soils and while various species are common as undergrowth in forests or as weeds in cultivated fields, they are generally found growing in shaded areas. Most flower in the fall.

While some species are used as a fodder, most are considered medicinally useful. Since the genus generally grows well in dry rocky soils and its rooting is well suited for preventing soil erosion, it is often grown in and around cultivated fields. Finally, the leaves may be used as a tea, the fibrous stems are suitable for paper making, the fruits are sometimes eaten and at least one species is commonly used as a dye-yielding plant.

<u>Digera.</u> (Amaranthaceae). One of the most common seed taxa recovered from the Rojdi soil was that of <u>D. muricata</u>. Nearly six percent (802 seeds) of the Rojdi archaeobotanical material belonged to this species. While at times their density in a given sample was high, overall <u>D. muricata</u> was one of the most well distributed seeds recovered. At least one seed of this taxa was recovered from 134 samples or in nearly 25 percent of the samples collected. From only three samples were more than 20 seeds recovered. These three samples, as well as 85 percent of the seeds, were from the South Extension portion of Rojdi. Only 36 seeds were from the Main Mound trenches. While a few seeds were from the lower stratum of the North Slope or South Extension regions, the overwhelming majority were from the upper levels. While some seeds were carbonized, most were not. A high percentage of the seeds of this species probably represent recent contamination.

The seeds are subspherical, muricate, pale-brown in color and range in size from 2.03 mm to 3.14 mm in diameter. The seeds and fruits are very distinct and match up well with comparative material. This annual erect herb grows well throughout the plains of India and can be found as a common weed in cultivated fields, pastures or in any well disturbed area or waste land. Besides being grown as a pot-herb when its tender shoots are eaten, the seeds seem to be relished by cattle. Its also has limited medicinal uses. <u>D. muricata</u>

was seen growing near Rojdi while the site was being excavated, and small numbers of its seeds were also recovered in control samples from areas off Rojdi.

Digitaria. (Poaceae or Gramineae). Of the 69 grains of *Digitaria ascendens* (Crabgrass or Finger Grass) recovered from Rojdi, only one was carbonized. All but two of these seeds were from the surface levels, supporting the view that they represent recent contamination. Of the 27 samples in which they were found, 16 were from the South Extension area, and eight were from the North Slope region.

D. ascendens is a common grass in Gujarat and can be found flowering during the summer monsoon in Saurashtra. This is a common weed often found in cultivated fields. There are at least six other species of *Digitaria* which can be found growing in Gujarat today. While the identification of *D. ascendens* is based on comparative material, seeds of the other species were not all represented in the comparative collection, so the identification is not definitive.

This widely distributed grass is found throughout the plains of India and is valued as a green or dry fodder. While there are records of *D. ascendens* being used as a cereal, there are references to other species of this genus being grown by Indian tribal populations as a food grain.

Dolichos biflorus. See *Vigna unguiculata*.

Echinochloa. (Poaceae or Gramineae). Twelve seeds which are thought to belong to the genus Echinochloa were recovered from Rojdi. All but three of the grains are well burned. While the seeds were from three different trenches, one from each region of Rojdi, they all were from Rojdi C occupations.

At least three species (E. colonum or Sawa millet, E. stagnina or Dul, and E. frumentacea or Japanese barnyard millet) are common in Gujarat. The 12 grains are broad-elliptic dorsally flat, ventrally convex and range from 1.87 mm to 2.11 mm in length. These grasses are annuals and perennials which grow best in wet places and in warm regions. They are cultivated and collected in the wild, and grow as a weed in water-logged fields under cultivation.

E. colonum, the species which most resembles the Rojdi grains, is also known as saura millet. It is valued as a quick growing grass where the harvest may take place within six weeks of sowing, which generally takes place in early summer. As a fodder grass it is relished by cattle. The seeds may be boiled like a rice, especially by poor people in times of scarcity. Though its nutritional value is poor, Echinochloa sp. is considered useful medicinally.

Eleusine. (Poaceae or Gramineae). Because of their provenience, density and dietary value, the 1326 grains of Eleusine sp. represent one of the most important botanical finds at Rojdi. All grains of this grass were from the Main

Mound and South Extension areas of Rojdi. Overwhelmingly, they were from the lower strata, although some seeds of Eleusine were recovered from strata representing each phase of Rojdi occupation.

The recovered seeds, all carbonized, look like Eleusine coracana (known as finger millet, or more commonly in India as ragi). All grains are small, globose to subglobose in shape, a small clearly depressed hilum, with the embryo in a dorsal position. Rojdi ragi seeds ranged in size from 1.31 mm to 1.67 mm in length and 0.83 mm to 1.19 mm in breadth. Seeds were smooth with a rugose ornamentation on the seed coat.

While a considerable amount of variability in seed size, shape and ornamentation pattern can be found for E. coracana depending on geographical and climatic regions (Sharma 1983:59-100), the Rojdi seeds representing this species show a lot of consistency in appearance. Although at Rojdi they show little variation in shape and size, they are smaller than modern grains grown in the region today, even after carbonization is taken into consideration. Based on the morphological characteristics, it seems safe to assume that only one variety of Eleusine was present during the occupation of the site. Of the five species of Eleusine which occur today in tropical and warm regions of India, only E. coracana is represented in the Rojdi record. The progenitor of this species is thought to be the wild grasses

of E. africana or E. indica found commonly in Africa. At present, there appears to be a consensus that based on comparative morphology, cytogenetics, geographical distribution, historical knowledge and linguistics, that E. coracana originated in Africa and was introduced into India three to five thousand years ago (Weber 1989b). The alternative view, not widely accepted, is that E. coracana evolved from the recently identified South Asian varieties of E. coracana subspecies africana and not the African species of E. indica (Sharma 1983:5768, Dixit et al. 1987). If true, this supports the intriguing possibility that the immediate ancestor of the commonly cultivated plant E. coracana is of Indian origin. It should also be noted that while E. coracana is cultivated throughout the world, there is currently no way to determine whether the carbonized seeds of this plant represent a fully domesticated species.

E. coracana can be found growing throughout Gujarat, including Saurashtra. There are many different races of this tropical crop grown, since it is very well suited for dry farming and it does particularly well as a rainfed kharif crop. This millet grows best in moist climates where the mean temperature is around 23°C throughout the summer growing period. Its water needs, based on rainfed conditions, is between 25 and 50 cm annually. It can be cultivated on a variety of soils, including the black cotton soils of

Saurashtra, as long as the soil is porous and does not become waterlogged.

As a cultigen, under rainfed conditions, *E. coracana* is often grown as a mixed crop in association with cereals (e.g. *Panicum*), pulses (e.g. *Vigna*) as well as other minor crops. After sowing in mid summer, ragi usually requires some management including hoeing and weeding, although plant diseases and insect pests are not a serious problem to this species. Depending on volume of water, soil conditions, temperature and specific race, *E. coracana* matures in three to five months. Dried stalks cut close to the ground are bundled and stacked for a approximately two months before threshing. Various methods are used to separate the grain from the dried earheads including beating with sticks, treading by bullocks or crushing with stone rollers. Subsequently the grains are winnowed and cleaned. An average yield under rainfed conditions is between 600 and 800 kg of grain and 1500 to 2500 kg of straw per hectare.

E. coracana grains can be stored for up to 50 years and have a nutritive value higher than rice and equal to wheat. The straw is considered a nutritious fodder for cattle. In many regions of the world, including portions of India, this species is the principal food grain. It usually is made into flour and then baked into breads and cakes, or boiled into puddings, porridge or a gruel. It can also be malted and used as a nourishing food for invalids or infants. A

fermented liquor can also be prepared from the seeds. Today, ragi is generally looked upon as a "poor man's" grain or a grain to use during time of scarcity.

Elyonurus. (Poaceae or Gramineae). Seventeen unburned seeds belonging to the species Elyonurus royleanus were recovered from Rojdi. All but one of these recently deposited seeds were recovered from the South Extension and all but two were from the upper 40 cm of soil. This herb can be found in Saurashtra, growing in sandy soils. It is most commonly found in late summer and fall. None of these seeds represent archaeological material.

Euphorbia. (Euphorbiaceae). Three different species of Euphorbia (spurge) have been identified from Rojdi, they include: E. granulata, E. prostrata, and E. thymifolia. They are represented by 1123 seeds from all areas and levels of occupation. They are carbonized and uncarbonized, whole and fractured, and probably represent both archaeological and recent material. Euphorbia is a large genus of laticiferous shrubs, herbs and small trees widely distributed in Gujarat and throughout Saurashtra. They generally inhabit dry areas and while they may resemble cacti, they are distinguished from them by the presence of a milky latex. Besides their medicinal properties, Euphorbia may be cultivated or used as hedge plants (a common practice around Rojdi), and are

considered useful as green manure in the reclamation of waste lands.

252 of the Euphorbia seeds are morphologically closest to E. granulata, based on comparative morphological material. The seeds are quadrangular, faintly pitted, and bluntly pointed, with an average length of 1.51 mm. Less than seven percent were carbonized or found below the surface strata. They probably represent recent contamination. While they are not commonly found today in Gujarat, they are reported to occur in some sandy locations. They are generally a winter flowering plant.

E. prostrata was represented by 652 seeds, of which, again, about seven percent were carbonized. Unlike E. granulata, a few carbonized grains were recovered form the lower strata of the Main Mound areas (Trench 46L). This means that the overwhelming majority of E. prostrata seeds were from the surface levels and found in an unburned state. The seeds were 4-angled, transversely grooved and averaged 1.50 mm in length. This species is commonly found throughout Gujarat as a weed in cultivated fields and in drying moist ground.

The final species of Euphorbia found at Rojdi was E. thymifolia, represented by 216 seeds. The seeds were brown, unburned or carbonized, obtusely 4-angled, glabrous and with five or six transverse grooves or furrows. This species can be found growing throughout the year in most regions of

Gujarat. It is a common weed in cultivated fields and has several medicinal applications. Due to its condition and surface strata provenience, it is considered a recent contaminant at Rojdi.

In general, Euphorbia is regarded as a recent contaminant, although a few seeds of E. granulata and E. prostrata may represent archaeologically significant material. In fact, it is quite likely that at least some E. prostrata seeds were deposited during the occupation of Rojdi.

Ficus. (Urticaceae). Sixty seven seeds belonging to the genus Ficus (Fig, Banyan or Indian Rubber) have been recovered from Rojdi. The seeds with their curved embryo, a membranous testa, and small oval shape, averaging 1.57 mm in length and 1.26 mm in breadth, could not be identified to species. All the Ficus sp. seeds, except those recovered from the surface of one trench (76M) were carbonized. Of the 30 carbonized seeds, 13 were well burned and from the lower levels of the Main Mound (Rojdi A and B). The carbonized and uncarbonized seeds may not represent the same species, indeed, the carbonized seeds may represent a number of different species.

Of the over 65 different species of Ficus which are known to exist today in India, nearly a third can be found in Gujarat. These trees and shrubs inhabit a large variety

of environments, including deciduous forests, shrub forests, river banks, and as a weed in waste places. Some species are cultivated for shade, for their edible fruits and in some cases, as a source of rubber. In addition, the leaves may be eaten by cattle and the wood used as a commercial timber. The plant also has various medicinal applications. Fruits of Ficus may be eaten raw, preserved for the future, or cooked into curries. Ficus is also a sacred plant for many tribes and is extensively referred to in the Rig Veda.

Fimbristylis. (Cyperaceae). Twenty-four plant parts belonging to the genus Fimbristylis. They were carbonized and from proveniences implying that their occurrence was due to factors other than recent contamination. The plant parts have a very distinct obovoid, trigonous, minutely stipitate and faintly ribbed appearance. They are tiny with an average diameter of about 0.48 mm. Of the nearly 20 species which can be found growing in Gujarat today, the Rojdi remains are most similar to F. tenera, although it should be noted that only a limited number of species of Fimbristylis are represented in the comparative collection.

Of the three trenches from which these nuts were recovered, two were on the Main Mound (45K and 46L) and one was on the South Extension (76H). All Fimbristylis sp. remains were from the middle and upper levels representing either Rojdi B, C, or C/D.

Fimbristylis sp. are common weeds in marshes, moist soils and wet cultivated fields. They are most evident during the monsoon season. Species of this sedge are used for matting, and are sometimes even cultivated for such use, other species are commonly eaten by cattle, or collected because of their aromatic properties and medicinal applications for dysentery.

Glossocardia. (Compositae). Fourteen achenes belonging to the genus *Glossocardia* (also known as *Verbesina*) were recovered. Based on the limited comparative material for the genus, they appear most like *G. bosvallia* (Siri). All are uncarbonized, and all but one seed was from the South Extension portion of Rojdi. All appear to be recently deposited, with only one seed not coming from the surface strata. While this annual herb is not commonly found in Gujarat it does occur, mostly in open plains. The achenes averaged about 6.11 mm in length, narrowly oblong, compressed, flattened, and densely hairy in the edges and on the flat faces. Besides having some medicinal uses, it is also eaten as a vegetable, especially in times of scarcity.

Goniogyna. (Papilionaceae). Sixty-one seeds of *Goniogyna hirta* (*Heylandia latebrosa*) were recovered from the Rojdi soil. No seeds were carbonized and all were from the upper strata. This species, whose occurrence is probably due to

recent contamination, was mainly recovered from the South Extension, though a few seeds were from the North Slope portion of Rojdi. The seeds were 1.83 mm to 1.22 mm in length, smooth, polished, subreniform, and ranged in color from brown and yellow to green. Oblong, flat and two-seeded pods were also observed. This herb is very common throughout Gujarat, and could be seen growing in the vicinity of Rojdi.

Hordeum (Poaceae or Gramineae). While only 13 grains of Hordeum sp. (barley) were recovered from Rojdi, their occurrence is significant in that it is a major food crop in some regions of the world, and was so in the Indus Valley. All barley seeds were carbonized and difficult to identify, especially to species and species variety. These grains were identified as Hordeum vulgare based on comparative material, and confirmed by three different archaeobotanists.

Eight grains were in soil representing trash from the lowest Stratum (8) of Trench 76N on the South Extension, two seeds were collected on the lowest level (23) of Trench 46L on the Main Mound, and three grains were from Stratum 2 of 45K, also on the Main Mound. The two grains from the lower levels represent the earliest occupation at Rojdi (A), the three grains from the upper levels were in soil deposited during the early historic occupation of Rojdi. Although all 13 grains were badly decayed they retain features typical of H. vulgare. They had deep ventral grooves with a shallow

dorsal depression, the embryo was positioned at the basal end and appeared horse-shoe shaped or like an inverted "V". While there was an enormous range in grain shape due to the state of preservation, the maximum breadth was in the middle region.

Barley grows best in sunny weather (average temperature 16°C). with a moderate amount of precipitation, and on light or sandy soil. In India it is generally grown as a winter or rabi crop, sown around October and November and harvested in early spring. It can be grown in irrigated and rainfed conditions, and is often planted with crops such as gram, lentil, mustard and linseed. It needs little weeding, although it needs more management if grown under irrigated conditions. Barley takes around four months to mature, when it is either pulled out or cut at the stock base. The grains are often threshed by beating with sticks or trampling by cattle. The yield of barley is based on moisture supply and method, soil type, and type of barley grown. The average yield ranges from 568 kg/ha to 1234 kg/ha.

Barley as a cultivated cereal is used as a human food and cattle fodder as well as for brewing and malting. It has good nutritional value. In India today, barley is generally ground into flour and mixed with flour from wheat and gram for preparing chapatis. The straw from <u>Hordeum</u> is used as a bedding or as a fodder for livestock.

Impatiens. (Balsaminaceae). Six seeds were recovered belonging to the genus of Impatiens. Since all these seeds were uncarbonized and in the upper stratum (Rojdi C), they probably represent recent contamination. While one grain could be identified as I. balsamina (Garden Balsam), the remaining five seeds could not be speciated. No Impatiens sp. seeds were observed on the Main Mound region.

I. balsamina, like other species of this genus, are common in Gujarat as well as Saurashtra, especially during the summer. They are most common in tropical and subtropical regions of India, in the plains and as a forest undergrowth. They are also often grown in gardens, for the seeds are edible, the oil may be used for cooking and burning in lamps, and the leaves serve several medicinal functions.

Indigofera. (Papilionaceae). At least four different species of the genus Indigofera were identified at Rojdi. Commonly known as either trailing, natal, Java, or wiry indigo. One hundred and seventy nine seeds in all were recovered which belong to this genus. The seeds were carbonized and unburned, from each region of the site and from various depths including the lower strata. Less than 10 percent are thought to represent archaeologically important deposits. Of the over 50 species of this large genus of herbs and shrubs which are found in India, nearly half of them can be found growing in Gujarat. While

Indigofera sp. is often considered a weed, some species are cultivated for the dye indigo, or their use as a famine food, a fodder, green manure, plant cover or medicine. In all, Indigofera sp. remains were observed in 64 different soil samples from 21 different trenches.

Seventy-eight of these seeds were identified as I. linifolia. The seeds were spherical, orangeish-brown, very shallowly pitted, smooth, shiny, and with an average diameter of around one millimeter. Their pods were also observed, one millimeter to two millimeters long, spherical with silvery white hairs, containing one seed per pod. All the seeds which were definitely identified to this species were not carbonized and were from the surface levels implying recent contamination.

Ten seeds could be identified as I. lochstetteri. The seeds were unburned, red-brown in color, rectangular with a protuberance at the hylum scar region, flattish, and shiny. Again, due to provenience and uncarbonized state, these probably represent recent contamination.

A third category of Indigofera was represented by hard, shiny spherical seeds and pods that hold two seeds. These uncarbonized seeds were also probably deposited recently although they could not be identified to species.

A final category containing 31 mostly carbonized appeared different from the previous three taxa, yet it could not be identified to species. These seeds may represent a

number of different species in this genus due to their range in appearance. No single sample contained more than three of these seeds, so their density was not great. The majority of these grains were from the mid and lower levels (Rojdi A and B) of the Main Mound and South Extension portion of the site.

Ipomoea. (Convolvulaceae). Four large carbonized seeds or seed parts have tentatively been identified as belonging to the genus Ipomoea. The four plant remains were from the upper and mid-levels of the main mound (Trenches 45K and 46K). They belong to fill associated with Rojdi C and the Early Historic strata.

Ipomoea is a large genus of herbs, shrubs and trees which includes such well known species as morning glory, swamp cabbage, sweet potato, and railway creeper. Over 50 species can be found in India today, over 20 of which occur in Gujarat. Besides being cultivated for their edible root tubers, they are grown for their ornamental and medicinal uses. Young shoots and leaves serve as vegetable greens.Species of Imopoea are cultivated in Saurashtra, generally during the summer months.

Lathyrus. (Fabaceae or Leguminosae). Eighty-six carbonized seeds similar in appearance to Lathyrus sativus (chickling vetch or grass pea), have been recovered from two trenches

(42L and 45K) on the Main Mound. The grains were small and wedge shaped with the hilum scar on one side of the thick end. Their length ranged from 2.16mm to 2.98 mm in length and 2.03 mm to 2.81 mm in breadth. The seeds were all recovered from between 120 and 175 cm below the surface, and associated with either Rojdi C or C/D.

This annual herb is cultivated in Gujarat today. It is grown as a pulse grain and for fodder. Since it may not be indigenous to South Asia, its occurrence needs to be explored further, although, based on the limited number of seeds, its use as pulse was probably limited. It is considered to be native of western Asia and southern Europe.

L. sativus grows in most types of soils and is generally cultivated as a cold weather crop. It is usually sown in the fall, often with other plants, and harvested before the pods are fully ripe, some four to five months later (between February and March). Little management, including weeding is needed. It is often harvested with other wild leguminous weeds. This may be the case at Rojdi, where samples with a number of grains of L. sativus also contained a variety of leguminous seeds. After the cut plants have dried for about a week they are threshed and winnowed. Yield ranges been 300 and 900 kg/ha of pulse and between 400 and 1,300 kg per hectare of straw.

Harvested seeds are often part of the diet of the poor or of people during times of scarcity. They may be ground

and used as a flour in chapatis or boiled and eaten like a pulse. Substantial and long-term consumption of this species by humans or livestock can cause the paralytic disease known as lathyrism. Occasional use of L. sativus in the diet appears to have no effect. Besides the seeds, the leaves are eaten as a pot-herb and can be fed green or dried to cattle or other animals.

Lens. (Fabaceae or Leguminosae). Only three seeds of Lens esculenta (lentil) were recovered from Rojdi. Due to their carbonized condition and decayed state, their identifications are tentative. The grains are lenticular, compressed or flattened, with a slight keeled margin, but the hilum scar and husk were not well preserved or observable. The mean diameter was 2.11 mm, with a mean thickness of 1.57 mm.

Two seeds were recovered from the mid strata in the Main Mound (45K and 46L). The third seed, similar in appearance to the other two, was from the mid levels of 76N on the South Extension. All three seeds are associated with Rojdi C occupation.

Lentils are associated with some of the oldest Neolithic sites in Europe and Western Asia. They are commonly found in the same sites with early types of wheat and barley. Today, lentils are grown extensively in India, including Gujarat.

The number of varieties of L. esculenta enable it to be grown in a wide range of soils and in a variety of climates. It grows well in the black cotton soils of Saurashtra. After some plowing, lentils are usually sown in the fall along with other rabi crops. It is usually harvested some three to four months later (February to March). It is cut at ground level and threshed after drying. The yield ranges from 400 to 700 kg/ha under dry conditions. Under irrigated conditions the yield may double.

Once threshed, the seeds are often dehusked so they can be used as a "dhal." Today, the husk is removed by moistening it with water or oil, letting it dry in the shade and then passing it through a mill. Lentil seeds are also ground into a flour and mixed with other cereal flours for later use. For pulses, the nutritional value of lentil is quite high, second only to Vigna angularis and Cicer arieutinum. The husks, leaves and stalks are used as a fodder in both a fresh and dried state. There are also a wide range of medicinal uses.

Linum. (Linaceae). Three very distinct seeds have been identified as belonging to the genus Linum (linseed). The seeds, all carbonized, were small, flattened or compressed, elliptic/oblong, glabrous and somewhat shiny. Their mean length was 1.28 mm with a breadth of 0.89 mm. Only two species can be found growing in Gujarat, L. mysrense and L.

usitatissimum. Both are rarely found growing in Saurashtra.

The three seeds appear similar in appearance but were recovered from three different soil samples, from two different trenches (45K and 76N). The two from the Main Mound area were from the upper layers associated with the Rojdi C and Early Historic occupation. The seed from the South Extension was recovered from the mid levels of a trash area, representing Rojdi C.

Linum is cultivated for its seeds as an oil crop (linseed oil) and can be found growing in the wild. L. usitatissimum is not found growing in a wild state and its origin prior to domestication is uncertain. While L. mysrense grows best during the summer and fall, L. usitatissimum is considered a cold season rabi crop. To date, these seeds cannot be identified to species.

Linseed is mainly a rainfed crop needing between 75 and 175 cm per year of moisture, mostly during the winter season. It does well on a variety of soils including the black cotton soils of Central India. In areas like Gujarat it is planted in September or October and harvested in February through March. It is often sown with barley, gram and jowar. The plants are cut at the ground, dried for a short time, then threshed and winnowed. The average yield, while dependent on many factors including species variety, ranges from 800 to 1200 kg of seeds per hectare. Oil may be extracted by heating the seeds, then crushing them. Modern sources report

that 40 percent of the yield from linseed goes to oil. Traditional use probably favored fodder, for early publications such as the Bombay Gazetteer (1886:215) suggest that only 22 percent went to oil and the other 78 percent was often fed to cattle. Although, the majority of linseed is produced for its oil, it has other uses such as stock feeding and for medicine.

Lotus. (Fabaceae or Leguminosae). While eight carbonized seeds have been identified as belonging to the genus Lotus (deer-vetch), it is a tentative identification for lack of proper comparative material. All eight seeds were from a single trench (45K) on the Main Mound. Five seeds were recovered together in one sample, the remaining three seeds were from three different samples. All seeds were from a depth of between 130 to 230 cm below the surface or associated with strata identified as belonging to Rojdi B or Early Historic occupations. The seeds appeared similar in that they were elliptical, glabrous and smooth with a length of about 1.37 mm.

The only species reported to occur in Gujarat today is L. garcini, which can be found in sandy areas along the Saurashtran shore. It is found flowering in late fall and early winter. It is not cultivated and can be used as a dye, animal feed or for medicinal purposes.

Medicago. (Fabaceae or Leguminosae). About 10 species of the genus Medicago (medick) grow today in India, of which four are found in Gujarat. Twenty carbonized seeds were recovered from Rojdi belonging to this genus. Five were identified as M. sativa while two grains could not be identified to species with any degree of certainty.

The five seeds belonging to M. sativa were all from the strata of 45K associated with the Early Historic levels. These kidney shaped seeds represent a plant commonly cultivated in Gujarat today. Although they are leguminous weeds often found in disturbed areas or dry river beds, M. sativa is highly valued as a legume fodder. It is a hardy, drought-resistant plant which needs only an annual rainfall of about 50 cm, and can be grown on a variety of soils. M. sativa is sown in plowed fields and can be grown throughout the year. Cutting for fodder takes place from one to two months after planting. This legume is especially common fodder for horses. All of the grains of Medicago sp. which could not be identified to species were from the upper levels of 45K and 46L (Rojdi C/D).

Melilotus. (Fabaceae or Leguminosae). Thirty-one well burned seeds possibly belonging to the genus Melilotus have been recovered from the site. Two species occur in Gujarat, both of which can be found growing in the wild or under cultivation around Rojdi today.

Seeds of Melilotus indica (yellow sweetclover, small flowered melilot) are similar to 16 of the seeds from Rojdi. They are all carbonized, oblong-ellipsoid, compressed, smooth and glabrous. Their mean length is 1.88 mm, and their breadth is 1.21 mm. M. indica is common as a weed in winter fields or cultivated as a cold season crop. It needs a good, fertile soil and moist conditions, and grows best in irrigated fields. It is sown in the fall and harvested as fodder from February through April. Besides being used as a green or dry fodder, or as a green manure, it has several medicinal applications. These seeds were recovered from the lower levels of 76N and from the upper levels of 45K and are associated with Rojdi A and the Early Historic periods of occupation.

The remaining 15 seeds were quite similar to M. alba (white sweet-clover, white melilot), although this identification is preliminary at best. These seeds are smooth, glabrous and somewhat globose. Their mean diameter is nearly one millimeter. While not common, M. alba is found growing in Saurashtra today. It is also cultivated as a fodder, generally in well drained alkaline soils under irrigated conditions. Like other Melilotus species, it is also grown in the fall and winter and used for green manuring and medicinal purposes, and as a fodder. The seeds in this category were from 13 different soil samples, from five different trenches. Although most were from the Main Mound

trenches, some seeds were from the South Extension and from the North Slope areas. The majority were from the upper strata, although one seed was from the lower levels of 46L.

Melochia. (Sterculiaceae). Six seeds belonging to the genus *Melochia* were recovered from the upper levels of four different trenches. The seeds were not carbonized and could be identified as *M. corchorifolia* or locally known as bilpat. They were angular and appeared mottled black-gray. They represent recent contamination of a plant found throughout Gujarat, especially in moist ground. Five seeds were from trenches in the South Extension and one was from a trench in the North Slope region.

The leaves of *Melochia* sp. can be eaten as a vegetable and the stem bark may be used as a fiber, or used medicinally. This herb is also a common weed which can be found flowering from summer through early winter.

Millets. The term "millet" will occur regularly in this work. It should be stressed that this is a collective term for a group of unrelated forage grasses known for their coarse seeds and has no specific classificatory significance (rather like the use of the term 'australopithecines' in paleoanthropology). Since this usage is well-established, and has the advantage of providing a point of continuity with the work of other scholars, I have retained it in this

dissertation. However, it is important to note the discrepancies that arise over which plants are to be considered millets. Sorghum bicolor, for example, in some contexts is refered to as a millet (as in India) and in others it is not (as in Africa). In this work the following species recovered from Rojdi will be refered to as millets: Eleusine coracana, Echinochloa colonum, Paspalum scrobiculatum, Panicum miliare, Setaria italica, and Sorghum bicolor.

Millets take up nearly 45 percent of the land planted to food grains in present-day India. They are grown for their grain and for their straw as a cattle fodder. Millets are all warm weather grasses which grow well in semi-arid zones, in soils of low fertility and in regions of moderate rainfall.

Neptunia. (Mimosaceae). Six seeds, all fragmented and carbonized, have been identified as Neptunia sp. (lajalu). The seeds all appear oblong, compressed, smooth, and shiny. Their mean length was 4.10 mm with a mean breadth of 2.57 mm. Two seeds were from the mid to upper levels of 45K (Rojdi C and C/D), and four were from the mid strata of 76N (Rojdi C).

Two species are found in Gujarat, N. oleracea and N. triquetra. Neither species is cultivated nor common in Saurashtra. The stems may be eaten as a pot herb and the

pods as a vegetable. Both species flower from summer through fall.

Panicum. (Poaceae or Gramineae). A reoccurring seed found throughout the Rojdi record is *Panicum* sp. Of the 1019 seeds belonging to the genus *Panicum*, most could be positively identified as *P. miliare*. The remaining seeds probably represent a number of different species, none of which could be identified. The following discussion of *Panicum* will be broken into these two categories, *Panicum* sp. and *P. miliare*.

Of the seeds labelled simply *Panicum* sp., over half are carbonized and from archaeologically secure proveniences. These seeds were recovered from over 50 different soil samples and from 25 different trenches, rarely in high densities. They were evenly distributed throughout all regions of the site and in all periods of occupation. Because of the range in their physical appearance, a number of different species were probably represented, yet they all share a number of features and are similar to a couple of species represent in the comparative collection, including *P. miliaceum* (also known as hog or common millet).

Panicum is a large genus of annual and perennial grasses which include both wild and cultivated species. Of the 10 different species found growing today in Gujarat, three are cultivated. Plants of *Panicum* sp. can be found growing in a variety of habitats including moist areas, sandy soils,

waste lands, shaded places or in cultivated fields as a weed. When it is cultivated, it is for fodder or for its cereal grains. It is grown in the summer in rainfed conditions, where the annual rainfall is between 50 and 75 cms annually. Panicum is considered a hardy millet which grows in a variety of soils (including poor ones), and while the seeds are relatively small, their nutritional value is good. It also has a long history of use dating back thousands of years in East Asia, South Asia, and Africa.

Only one type of Panicum seed, P. miliare, appeared consistently, in large numbers from single samples (high density), and was always carbonized (also referred to as P. sumatrenae or little millet). It is a very tiny elliptic-ovate grain with a subbasal hilum. In a carbonized state it has a mean length of 0.88 mm and a mean breadth of 0.35 mm.

This little millet was recovered from only seven trenches, yet from 99 soil samples within these trenches. The seeds were recovered from two regions, 79 percent from the Main Mound, and 21 percent from the South Extension. In some areas, the density of this species was quite high, including samples which contained more than 22 seeds per liter of soil. The majority of these seeds were from floor and trash areas, with small amounts in general fill.

This annual grass grows wild in northern India and is cultivated today throughout Gujarat. The origin of the little millet is debated, with India and Southeast Asia among

the candidates. One possible ancestor for P. miliare is P. psilopodium, a grass commonly found growing in the wild throughout much of Southeast Asia.

Based on examination of modern seeds of P. miliare represented in my comparative collection, a great deal of variation in the shape, size and color of the grains exist. This probably reflects the adaptability and yield of various varieties of the species.

Little millet grows well in many soils which cannot support other crop plants. It has the lowest water requirements of any grain crop and grows well on any kind of soil (except coarse sand). It is sown during the rainy season and is harvested from fall through winter. This millet is often cropped with other millets (e.g. finger millet or horse gram). The yield, based on rainfed conditions, ranges from 250 to 800 kg/ha for the cereal grains, and from 800 to 1,000 kg/ha for straw. While its nutritional value is good, both straw and seed production are poorer than wheat or Eleusine coracana. The grains can be cooked like a rice and eaten or ground into a flour for making chapatis, puddings and cakes.

Paspalum. (Poaceae or Gramineae). Seven seeds representing recent contamination belong to the species P. scrobiculatum. Three seeds were from the surface levels, unburned and in a very fresh state. The remaining four grains were slightly

carbonized and are associated with Rojdi C strata. This annual grass (kodo millet) is commonly cultivated on alluvial soils in Gujarat. While it can be found growing in the wild, it is considered a hardy, drought resistant crop which grows well on a variety of soils and in conditions with moderate amount of rainfall. Kodo millet is sown in June or July and harvested some four of five months later in the late fall or early winter. It is grown both as a fodder and a cereal grain. After the grain has been dehusked, it needs to be stored for six months before being used as a food since immature grains are thought to be poisonous. When ready to eat, the grain is prepared like rice or ground into flour. The plant also has extensive medicinal uses.

This annual grass is sometimes found wild but it is generally seen in cultivated fields today. The wild forms are thought to be short-lived perennials. In Gujarat, four distinct races can be recognized based on the shape of the panicle. Although not much is known about the origin of kodo millet it is thought to be a native of India. It is a hardy, drought resistant crop which grows well in areas where rainfall is between 25 cm and 75 cm. While it grows in a variety of soils, it is often planted on inferior outlying land. Seeds are generally planted in June-July, often mixed with rice, and harvested four to six months later.

<u>Peltophorum.</u> (Caesalpiniaceae). Eleven seeds and some pods of <u>Peltophorum</u> were recovered from two regions of Rojdi, the North Slope and South Extension. The seeds were all from the upper strata and while a few of the grains were slightly carbonized, they probably represent recent contamination of the archaeological soil matrix. One species, <u>P. pterocarpum</u> (known as copper pod or rusty shield bearer) can be found growing in Gujarat today. The seeds and especially the pods from Rojdi are similar to their modern counterparts. The pods were lancelate, dark brown and woody, while the seeds appear obovate to oblong, smooth and glabrous.

Today, these trees can be found in some Indian gardens and along many roads. The wood may be used in construction, the bark as a dye, and the leaves can be used for cattle feed.

<u>Phyllanthus</u>. (Euphorbiacidae). Seventy-four seeds, most carbonized, were recovered from three levels of occupation. Three seeds were identified from Rojdi B, seventy were from Rojdi C, and one from Rojdi C/D. This weed probably represents a contaminant either occurring during the occupation of the site, or more recently. The seeds were all trigonous in appearance.

<u>Phyllanthus</u> is native to Western India and Pakistan. Twenty four species grow wild in India today. It is a herb that occurs as a winter weed throughout hotter parts of

India, especially in cultivated lands. It is bitter tasting, and has medicinal properties. There is no reference to its being used for food.

Pisum. (Fabaceae or Leguminosae). Six well burned and fragmented seeds have been tentatively placed in the genus Pisum. These seeds are globular and smooth. Their mean diameter is 2.38 mm. All the seeds were from the same trench (45K), but from different soil samples. They were associated with the strata belonging to Rojdi C/D. These grains may represent P. sativum (pea), the only species of this genus presently occurring in Gujarat. It is an annual herb cultivated for its edible seeds and as a fodder. It is not believed to be indigenous to South Asia.

P. sativum can be grown in a garden or as a field crop. It is a cold weather crop grown in the rabi season. It grows best in a mean temperature of 21°C and on loam or clay loam soils. It is generally sown in late fall, sometimes with wheat, barley or mustard, usually in irrigated fields, and if interest is in the seeds, it is harvested in the winter. Yields range from 500 kg to 900 kg/ha depending in variety, climate, soil, and stage of growth in which it is harvested. The seeds and pods are both nutritious. The green plant, the grains, the pods, and the hay, are all valued and used extensively as fodder. The plant also has some medicinal properties.

Polygala. (Polygalaceae). Only one seed belonging to Polygala (milkwort) was recovered from Rojdi. While the species could not be determined, it is a very distinct looking seed. It is ellipsoid/oblong, strophiale 3-lobed, and densely hairy. It came from the surface strata of the South Extension and represents a recent deposit. A number of different species of this genus are common for Gujarat. While it is widely distributed in warm temperate regions, the habitat of each species varies as does the season in which it flowers. Some of the species of this genus may be used medicinally, or portions consumed as food. Polygala is not cultivated in India today.

Polygonum. (Polygonaceae). From two different trenches (46K and 76L) six carbonized achenes of the genus Polygonum (smartweed or knotweed) were recovered. They are all carbonized, trigonous, glabrous, somewhat acute at the ends, with a mean length of 1.57 mm and breadth of slightly over one millimeter. Based on comparative material, the nuts are most like P. plebeium, a common herb found throughout Gujarat. P. plebeium is even common in Saurashtra, where it grows abundantly in wet earth that is in the process of drying. The Rojdi seeds were all from strata associated with Rojdi C occupation.

P. plebeium, like many other species of Polygonum, can be used as a vegetable or medicinally depending on the part

of the plant used and method of preparation. The plant is generally seen from fall through spring. It is collected in the wild and not cultivated.

Rorippa. (Cruciferae). Four seeds of this recent contaminant were recovered from the surface level of one trench in the South Extension. These reddish-brown, smooth, glabrous, nearly spherical seeds were not carbonized. One species, *R. indica* (cress), is found throughout Gujarat today, mostly as a weed in moist soil. While this herb is not cultivated it does have medicinal uses. It is generally found flowering in the fall.

Saccharum. (Poaceae or Gramineae). A genus well distributed throughout the surface strata of Rojdi is *Saccharum* (sugarcane or nobil cane). Three hundred and fourteen unburned spikelets and seeds were recovered, all representing recent contamination. They were found in all locations of Rojdi, and at various depths, although the overwhelming majority were from the surface of the South Extension. Species of this perennial grass are common to Gujarat as cultivated and wild plants. *Saccharum* generally flowers in the fall and can be found growing on dry sandy soil. Many of the species are indigenous to South Asia, although there are no archaeological traces of them at Rojdi.

The best known species of Saccharum is the sugar cane, a very commonly cultivated plant in India. Since species of Saccharum could be seen growing wild around Rojdi, it is most likely that it is one of these species that is recovered in the Rojdi soil. The only real use of the wild varieties is as fodder, although the grains of some species are eaten in times of scarcity.

Sapindus. (Sapindaceae). One seed of the genus Sapindus (soapnut-tree), unburned and probably representing recent contamination, was recovered from the surface level of a trench in the South Extension (76M). Two species, both flowering in the winter, are common to Gujarat. Some species of this tree produce fruits which are collected for their detergent properties. It is planted for its fruit or for shade, but is also found in the wild. The seeds most resembled those of the species S. laurifolius, although this identification is preliminary.

Scirpus. (Cyperaceae). Four nuts belonging to the genus Scirpus (bulrush) have been recovered from Rojdi. They are nearly two millimeters across, obovoid, trigonous with a small conical tip. All were carbonized and from the Main Mound or the South Extension. They came from different trenches and are associated with different periods of occupation (Rojdi B, C, C/D). Due to the lack of comparative

material it was not possible to tell which, of any of the 12 species of Scirpus which grow in Gujarat today, is represented by these remains from Rojdi.

Some species of Scirpus are cultivated, yet the majority grow wild. The seeds of some are edible, others are used as a basic material used in mats and baskets, still others are used as fodder, green manure or roof covers. The tubers can be eaten raw or dried and ground into flour. The genus has extensive medicinal uses, depending on species. This herb is a spring or summer plant, and is usually found in marshy places or on the bank of a stream.

Setaria. (Poaceae or Gramineae). Nearly 10 percent of all the seeds recovered from Rojdi and over 15 percent of the archaeologically significant seeds belong to the genus Setaria. This is a large genus of annual and perennial grasses. About 25 species occur in South Asia, of which five are found today in Gujarat. Setaria includes grasses which are cultivated and grow in the wild, and species that are used for their cereal grain as well as fodder. While the 1696 recovered seeds may represent many different species of Setaria, so far only three have been identified, although a few of the seeds have been kept in the Setaria sp. category because they could not be identified to species. Each of the three species of Setaria (S. tomentosa, S. glauca, S. italica) will be discussed independently. It should be noted

that these remains were found in a carbonized and uncarbonized state, from all regions of the site, and with a ubiquity rate of over 50 percent.

One hundred and thirty one of the *Setaria* seeds probably belong to the species *S. tomentosa*. The grains were elliptic to ovoid, or slightly oblong and laterally compressed. The palea on the dorsal surface has a faint chess-board pattern and the upper lemma is thick, boat-shaped. The ornamentation pattern is irregularly rugulose. The grains are small with mean dimensions of 2.03 mm in length, 1.01 mm in breadth and 0.79 mm in thickness. Over half the seeds were carbonized, and while these dimensions are for those burned grains, the uncarbonized seeds did not differ in size significantly.

The seeds of *S. viridis* are similar in shape and size to those of *S. tomentosa*, yet since *S. viridis* is rarely found today in the plains of India and is not listed by Shah (1978) as occurring in Gujarat, (unlike *S. tomentosa*), it is more likely that these Rojdi grains represent *S. tomentosa*.

The carbonized grains, like those which were not burned, were mostly recovered from the upper levels of the site (Rojdi C). Only 17 carbonized and two uncarbonized grains of *S. tomentosa* were from strata associated with Rojdi A and B. Slightly over half of the carbonized seeds as well as 40 percent of all grains belonging to this species were from the North Slope region of Rojdi. The remaining grains were

evenly divided between the Main Mound and South Extension. S. tomentosa seeds were recovered from 68 different soil samples representing 25 different trenches.

Today in Gujarat, S. tomentosa is found growing in hedges and as forest undergrowth. It is an annual grass which can also be found growing in the back gardens of village houses (Vishnu-Mittre and Savithri 1976:560). The grass is eaten by cattle and its growth correlates well with the monsoon season. In contrast, S. viridis is found in more mountainous regions like the Himalayas. While this annual also grows in the wild, it is at times cultivated. It is considered a drought resistant plant useful for its grain and as a fodder.

The second species of Setaria tentatively identified in the Rojdi seeds assemblage is S. glauca. Six hundred and thirty six seeds from 104 soil samples and representing 43 trenches, were recovered form the Rojdi soil. Like the S. tomentosa seeds, they came from all regions of the site and over half were carbonized.

The seeds are ovoid, convex, and while transversely rugose, the upper lemma is coarsely rugose. Its mean dimension in a carbonized state was 3.91 mm in length and 1.72 mm in breadth. The North Slope region yielded 70 percent of the S. glauca seeds. In contrast, the Main Mound trenches were only represented by 57 seeds (nine percent) and from the South Extension, 131 seeds were recovered (20

percent). The uncarbonized seeds of S. glauca were almost all recovered from the same location where large amounts of carbonized seeds were also found. Ninety three percent of the seeds representing this species were from the upper strata of Rojdi, mainly those associated with Rojdi C. Only two carbonized seeds from secure proveniences could be associated with either the Rojdi A or B occupation. Almost all the seeds from the North Slope region of this site, whether carbonized, slightly carbonized or uncarbonized, were located just below a dense layer of broken sherds. Based on numbers of S. glauca to volume of soil, this location represents their location of greatest density. It is believed, based on provenience and associated artifacts, that all the seeds of S. glauca, except those unburned surface seeds, are associated with the occupation of Rojdi.

S. glauca, also known as yellow foxtail millet, is common throughout Gujarat today. It is an annual grass found cultivated and wild. It grows well in light soils, with moderate rainfall, and though it grows throughout the year, it flourishes best during the monsoon. If cultivated, it is sown in June and harvested in October, and needs no irrigation, manure, or attention between planting and harvesting. Under wild or cultivated conditions, yellow foxtail millet is a good fodder for cattle and is used as a grain for food. It can be ground into flour or boiled prior to eating.

The final and most abundant identifiable category of Setaria occurring at Rojdi is thought to belong to S. italica. Eight hundred and forty seeds, from 160 different samples and 44 different trenches, have been recovered from Rojdi. As with the other species of Setaria, all regions of the site and all occupations are represented. The carbonized specimens of S. italica appear ellipsoidal or globose-ellipsoidal, with a slight dorsal dome and tightly fitting lemma and palea on the ventro-lateral sides. Their surface pattern is irregularly rugose and their mean dimensions are 2.41 mm in length and 1.43 mm in breadth.

S. italica or foxtail millet, is a common cultigen throughout Gujarat and is found growing in Saurashtra. Its origin as a cultivated cereal is unknown and it could have been domesticated anywhere in Eurasia. While taxonomists have yet to agree on a wild ancestor of S. italica, it is considered by many to be S. viridis. Where in India there is a wide distribution of morphological variants of foxtail millet, the oldest finds from secure archaeological proveniences are in the highlands of Central China some 5000 years ago (Rao et al. 1987:109-115). While there was a great deal of variation in the size and shape of the S. italica seeds from Rojdi, they compared well with modern seeds being grown in India today. The range in variation may reflect the efforts of farmers to select a range of phenotypes with

different ripening times. This helps minimize storage arrangements by ensuring harvesting over a range of seasons.

The uncarbonized seeds of S. italica, representing 48 percent of foxtail seeds, were generally recovered from the location where the carbonized grains were densest. The upper strata of the North Slope region, associated with the Rojdi C occupation, contained nearly 70 percent of the recovered foxtail millets, where their density was in the range of three seeds per liter soil. Like the S. glauca from this region of Rojdi, the S. italica was also mainly recovered beneath a layer of sherds thought to represent fractured vessels. Of the 143 seeds recovered on the Main Mound and the 228 seeds recovered from trenches located in the South Extension, only 15 seeds were from the lower levels representing strata associated with Rojdi A and B occupations. Again, as in the case of S. glauca, the majority of the S. italica remains, even those from the upper levels of the site and found in an uncarbonized state, probably represent archaeologically deposited seeds. Although, until the actual seeds themselves are dated by the accelerator dating method, there well be a certain level of doubt in this regard.

S. italica can be grown on a variety of soils including black loam soils. While it can be grown throughout the year, it grows best as a monsoon season crop. It is often sown in May, June or July, and again in August or September to yield

three crops. The crop takes 90 to 120 days to mature depending on the variety of soil and amount of moisture. It grows best when the rainfall ranges from 50 cm to 75 cm and can still produce a crop if rainfall is limited to two months. For this reason, foxtail millet is often a preferred crop where the amount and distribution of rainfall is uncertain. Under rainfed conditions, *S. italica* is often sown with *Sorghum* or *Dolichos lablab*. When grown as a pure crop, it is sometimes rotated with *E. coracana*. Once fields are prepared and *S. italica* has been planted, the only attention the crop is given is one hoeing and weeding some three weeks into the growing period.

Unlike other rainfed crops, there appears a high level of uniformity in plant height and head size. The heads are generally cut and threshed upon maturing. The normal yield under rainfed conditions is between 400 and 1,300 kg/ha for seed grains and the average straw yield is up to 2,200 kg/ha. The leaves of foxtail millet can be used as a pot herb, but farmers grow the plant primarily for grain. After husking, the grains can be parched and eaten, ground and eaten in the form of cakes or boiled, and made into a porridge. They can also be malted and made into a beer, or used for numerous medicinal purposes. Seeds are also used to feed caged birds and poultry.

The straw is considered a good fodder and can be fed to cattle. *S. italica* straw is not used as a fodder for cows

since it tends to reduce the secretion of milk in lactating animals and may induce abortion. The straw may also be used in house construction and for bedding.

When Setaria tomentosa, S. glauca, S. italica, and the additional unidentified Setaria sp. seeds are considered as a group, it becomes apparent that most of the remains are associated with the fragmented vessels in the North Slope, and that most of the seeds are carbonized and associated with Rojdi C occupation.

Sida. (Malvastrum). One seed, slightly charred, is though to belong to the genus Sida (mallow). It was recovered from the lower levels of 45K and is glabrous, smooth and cuneate. It could not be identified to species due to the lack of comparative material. Not only is it associated with the Rojdi A occupation but it was also recovered in close proximity to the bins near the bottom of the trench.

This genus of herbs is well distributed throughout the tropics. Of the dozen of so species which occur in India, of the six reported for Gujarat, three are common throughout Saurashtra. Often considered weeds, Sida ripens during the fall, at the end of the monsoon season. Some of the species of this genus are medicinally important, others are useful for their fiber, and still others are cultivated during the monsoon.

Solanum. (Solanaceae). Seeds of at least four different species belonging to the large genus Solanum (nightshade) have been recovered from Rojdi. Of the 65 Solanum sp. seeds recovered from Rojdi, 39 were unburned and represent recent contamination. These appear flat, brown in color, glabrous and semi-spherical. They are most similar to S. melongima seeds. These 39 seeds were from the upper strata of the North Slope and South Extension.

The second species is represented by 14 carbonized, nearly spherical smooth surface seeds. They were all recovered from the upper-mid levels of trenches in the Main Mound and South Extension, and are in strata associated with Rojdi B and C material.

Eight carbonized seeds identifed as Solanum are subspherical, compressed with slight concentric rings were recovered from the mid-upper stratum of 45K, are associated with Rojdi C and the early historic occupation. These eight seeds are all very distinct from any other recovered seed yet are comparable to a number of different modern Solanum sp.

The final category of Solanum seeds consisted of four carbonized seeds. All four seeds were semi-spherical, flat and smooth. Their mean dimensions were 2.01 mm by 1.43 mm. Again, all four seeds were recovered from the upper-mid levels of 45K (Rojdi C and C/D).

The seeds of Solanum sp. were from 40 different soil samples and represented 14 different trenches. None of the

carbonized seeds were from the North Slope. Since this genus represents species which are sources for food, fodder, oil and folk medicines, the occurrence of this genus at Rojdi may be significant. Of the over 50 species of Solanum sp. found growing in India, at least eight can be found in Gujarat today. Many of these eight species can be found growing wildly as a weed in many parts of Saurashtra, while others are cultivated. They can be found throughout the year, though growing best from fall through the winter. The fruits, leaves, young shoots and roots can all be eaten and were cultivated or collected in the wild depending on the species.

Sorghum. (Poaceae or Gramineae). Possibly one of the most significant finds at Rojdi was 113 carbonized seeds belonging to the genus Sorghum. The seeds in general appear broadly elliptic to obovate, with an embryo scar which is elliptic or elliptic-rotund and over half the length of the seed. Its mean dimensions are 3.10 mm in length and 3.00 mm in breadth. While the seeds are most similar to S. bicolor, it is possible they represent another species of this genus. There are at least 12 species, 45 varieties and 145 races of Sorghum under cultivation in India today, and therefore the task of determining which of these are represented at Rojdi is difficult. On top of this, there are a number of wild species which also occur throughout India including regions

of Gujarat. Sorghum sp. is also known as the great millet or jowar. Present evidence, based on linguistic, morphological and genetic studies, place the origin of Sorghum cultivation in eastern Africa (e.g. Harlan 1977, Weber 1989). The present, limited archaeological evidence seems to support this view, although Arabia, Burma or India are not ruled out by some.

The 113 seeds of Sorghum were from only three trenches (45K, 46K and 46L), all on the Main Mound. No seeds were recovered from a depth greater than 175 cm below the surface. Of the 13 soil samples from which these seeds were recovered, four accounted for 88 percent of the seeds and one of these samples actually contained over 50 percent of the total Sorghum. While at this one location Sorghum had a density of 8.6 seeds per liter soil, the average for this stratum was 1.6 seeds of Sorghum per liter soil. The remains of Sorghum are associated with two occupations, Rojdi C and the Early Historic. Because of the importance of their occurrence, some of the seeds themselves need to be dated, to ensure that they do indeed originate in these two occupations.

The following discussion focuses on S. bicolor, the most likely identification of the Rojdi remains. Many of the other wild and cultivated species of Sorghum grow, and are used in similar ways to S. bicolor. In most cases it is a source for food and fodder and this plant ranks fifth in

acreage of world crops and third in importance in India after rice and wheat.

Sorghum grows best in areas having an annual rainfall of between 50 cm and 100 cm, although it can grow in areas with as little as 25 cm from the time of sowing to harvesting. In areas like Gujarat, it is rarely cultivated under irrigated conditions. The ideal temperature for *Sorghum* is between 26°C and 32°C during the growing season. It grows well in a variety of soils including black cotton soils.

While *Sorghum* is at times grown as a winter kharif crop (e.g. in southeast India), in areas like Gujarat it is planted as a rabi crop at the end of the monsoon in October. It is sown after the field has usually been plowed two to three times. Weeding is only performed about two weeks after germination. *Sorghum* is frequently sown with horse gram, pearl millet or Italian millet, and matures in three to five months depending on the variety. After the plant has been cut and dried, the ears are removed, threshed by hand using sticks, under the feet of cattle or with stone rollers. Subsequently the grain is winnowed and dried. The yield of grain, although dependent on many factors including variety, soil, moisture, and various cultural practices, is usually 500 to 1000 kg/ha. For green fodder it is around 10,000 kg/ha.

While in many areas of the world *Sorghum* is mainly grown as a fodder, in India it is one of the most important food

grains. The grain is often cooked like rice or ground to flour and cooked into chapatis. It can also be malted and used in brewing. The stalks of the mature plants are considered a good quality fodder. The grain is also used as a livestock feed. As a green fodder, dry roughage or silage, Sorghum is considered superior to other plants, including E. coracana, and P. scrobiculatum. Besides various medicinal uses, Sorghum is also pressed into a cooking oil, and into a sugary syrup.

Stellaria. (Caryophyllaceae). Nine carbonized Stellaria sp. (chickweed or starwort) seeds were recovered from the mid-upper levels of 45K. All nine seeds are associated with the Rojdi C occupation. These tubercle seeds were all roundish and flat with radiating grooves or furrows. Their mean diameter was about one millimeter. Stellaria is common throughout temperate regions, especially on the plain of India. It is a genus of annual or perennial herbs often thought of as common weeds. While there is some reference to Stellaria being grown as a green manure, it is generally regarded as a troublesome weed found in cultivated fields. It is used as a fodder for cattle and has various medicinal uses.

Tragus. (Poaceae or Gramineae). One hundred and fifty-six recent remains belonging to the genus Tragus (bur grass) were

recovered from the upper strata of all regions of Rojdi. The remains consisted of mostly uncarbonized spikelets. Six of these spikelets managed to contaminate soil collected from one meter below the surface. Only one species has been identified as growing in Gujarat, T. biflorus. This grass occurs infrequently in Gujarat and is found mostly in dry plains after the monsoon. Although it has some use as a fodder, its use as such is limited due to its small growth and harsh prickly inflorescence. T. biflorus is also a common weed in cultivated fields besides having some limited medicinal uses.

Trianthema. (Aizoaceae). The most common seed recovered from Rojdi belonged to the genus Trianthema. A total 2,729 seeds or nearly 20 percent of the Rojdi seed record is represented by this genus.

They were recovered from 44 different trenches or from nearly every trench excavated at the site. Further, over half (263) of the soil samples collected contained seeds belonging to this genus. Based on modern comparative material, three species of Trianthema were identified. Eighty-three seeds (T. portulacastrum) were reniform with faint wavy ribs and mean dimensions of 1.53 mm in length, 1.03 mm in breadth, and about 0.48 mm in thickness. Two hundred and twenty four seeds appear orbicular and compressed with concentric broken undulating ridges. These compare well

with T. triquetra, and have a mean dimension of 0.98 mm in length, 0.78 mm in breadth and 0.49 mm in thickness. The final identified species was T. decandra and accounts for the remaining 2,494 Trianthema seeds. Although Shah (1978:339) refers to this species as Zaliya decandra, all other sources as well as the labels on the pressed plants from which the modern comparative seeds of this species were recovered refer to it as Trianthema decandra. The seeds were orbicular or reniform, striate, with numerous faint concentric ridges and a notch at the helum region. Their mean dimensions is about 1.73 mm in length, 1.72 mm in breadth and about 0.63 mm in thickness. The seeds of these three species were carbonized and unburned, from all regions and depths, and can be associated with each level of occupation including the Early Historic. They are common for Saurashtra today, indicating that some of these seeds undoubtedly represent recent contamination.

All eighty-three seeds of T. portulacastrum (locally known as santhi) were carbonized, from the upper strata and from trenches representing each region of the site. This species is basically associated with only the Rojdi C occupation. It is a prostrate succulent herb which can be found throughout Gujarat and grows throughout the year. It is a common weed in cultivated fields and in waste areas, and can become an aggressive weed which harmfully contaminates other food grains or agricultural seeds. The leaves and

stems can be boiled and eaten as a vegetable, besides being used medicinally. It grows most profusely during the monsoon season.

Slightly over 20 percent of the T. trequetra (locally known as pathar phor) seeds appear carbonized. The 18 seeds from the North Slope and from surface strata were uncarbonized, implying recent contamination. Of the 32 seeds of T. trequetra recovered from the Main Mound, most were carbonized and associated with Rojdi C and Early Historic strata. Seventy seven percent of the seeds representing this species were recovered in trenches located in the South Extension. Although six carbonized seeds were recovered from the bottom of 76L, the majority of the seeds were from the upper strata associated with Rojdi C. There was also a larger number of uncarbonized seeds representing recent deposition from this region of Rojdi. This prostrate herb grows well on sandy dry soils. It is an aggressive weed found in Saurashtra as well as throughout India. While it grows throughout the year it is most common between August and September. There are no references of this plant as being used medicinally, as a food, or for fodder.

Seeds of T. decandra (known locally as gadabani) were more widely distributed in the Rojdi soil matrix than any other plant remains. Most of the 2,494 seeds were from the upper levels of the site. Few of the uncarbonized seeds were from the lower levels of any trench. While the density of

T. decandra was usually low, at several surface level samples yielded up to 32 seeds per liter soil. While a few carbonized seeds of this species were found in the lowest levels from each region of the site, the majority of the grains represent Rojdi C and Early Historic occupations. This prostrate herb, like other species of Trianthema, is a common weed. The leaves of T. decandra are eaten as a vegetable in times of scarcity and the root has some medicinal properties.

Since all these species of Trianthema are aggressive weeds which grow well in disturbed areas, have limited uses as either food, fodder or as medicine, and are never cultivated, their occurrence at Rojdi may be useful in measuring the amount of disturbance in each period of occupation.

Verbascum. (Scropholariaceae). Thirty-five seeds belonging to the genus Verbascum (cow's lungwort or common mullein) were found in the upper strata from all regions of Rojdi. The seeds were oblong, wrinkled, finely pitted, and minute. Although a few grains showed signs of carbonization, most of the seeds were unburned and from the surface levels signifying recent contamination. If they are associated with any level of occupation it would be Rojdi C and Early Historic. Verbascum sp. seeds were recovered from 17 soil samples representing only six trenches.

One species of _Verbascum_ is common throughout Gujarat today, that being _V. chinense_ (Shah 1978:510). This is a common weed, especially in cultivated fields or disturbed areas and can be found growing throughout the year. While some species of this genus are used as a garden plant, it is mainly used for medicinal purposes.

Vicia. (Fabaceae). Only two carbonized seeds have been _tentatively_ identified as belonging to the genus _Vicia_ (vetches, broad bean or field bean). Both seeds were from the mid-upper levels of the Main Mound, Trenches 42L and 45K. They appear to be associated with Rojdi C and C/D strata. While _Vicia_ sp. are cultivated mainly for their fodder and green manure, in Gujarat they appear generally as weeds, often in cultivated fields. The seeds of some species are eaten by humans or used as animal feed. _Vicia_ is basically found growing in disturbed soils in northern temperate regions. Of the nearly 12 species of _Vicia_ which are found in India today, only two are represented in Gujarat.

Vigna. (Fabaceae or Leguminosae). While only 52 seeds belonging to this genus were recovered, they represent an important part of the Rojdi botanical record due to their importance as either a food or forage. These carbonized seeds can be divided into four categories (based on their species identification), each of which will be discussed

separately. All Indian species formerly classified as Vigna, Phaseolus or Dolichos have been transferred to Vigna. Therefore, the following discussion will include the following four taxa: Vigna radiata, also known as V. radiatus and green gram; V. angularis, also referred to as Phaseolus mungo or black gram; and V. unguiculata, also found under the names Vigna sinensis, Dolichos biflorus and horse gram; and Vigna sp. a general category for seeds unclassifiable as to their species, although they could be placed in the Vigna, Phaseolus, and Dolichos genus.

Five seeds, all from the mid-upper strata of the Main Mound have been identified as V. radiata. These squarish or globular seeds measure about 2.57 mm by 1.82 mm, have a flat marginal linear hilum. They are slightly smaller and broader than black gram though they show many similar characteristics. Their depth and provenience imply an association with the Early Historic occupation or possibly Rojdi C.

Green gram, also known as mung, is one of the most important pulses grown in India today. It is presently believed that the origin of mung is Central or South Asia. In Gujarat, where it is a major crop, it is cultivated as a kharif and a cold season crop. It grows well in the deep, well drained black loam soils of Gujarat. Green gram is often sown with Sorghum, which is interesting since all five seeds (from four different samples) were found in association

with _Sorghum_ seeds. After planting and occasional weeding, some 80 days pass before harvesting. If the green pods are gathered for use as a vegetable, the plant is collected about three weeks prior to when the pulse is ready for harvesting, so that the pods will not shatter. It is generally planted during the rainy season, and harvested between October and November. After the hand picked pods have dried in the sun for two to three days, they are threshed with sticks or under the feet of cattle. Then they are winnowed, usually in baskets. The empty pods and chaff make good food and are often stored for such use. When mung is planted on its own, yield averages 400 kg/ha, and when sown jointly with other crops, its yield drops to about 200 kg/ha. The pods can be eaten as a vegetable, the ripe seeds boiled whole or split into dhal, the seeds can be parched and made into a porridge or ground into flour. It can also be fried in fat and salted, then eaten as a snack. Green gram is a major pulse crop in Gujarat and constitutes a valuable portion of the diet for many people throughout India. Its flour can be used as a soap substitute for cleaning the body. It also has medicinal uses, can be fed to cattle and is occasionaly grown for use as a green manure. Eighteen seeds have been identified as being _V. angularis_, commonly called black gram. They are distinguishable from _V. radiata_, although these two species look very similar. Other names for _V. angularis_,

such as P. mungo, should not be confused with mung (green gram).

The Rojdi seeds are rectangular to nearly spherical, smooth, and with a poorly preserved hilum scar centrally placed. The mean dimensions are 3.52 mm by 2.53 mm. Black gram is indigenous to South Asia and was a major cultivated pulse in prehistory, as well as today. Seeds were from the mid levels of the Main Mound and from the lowest levels of one trench on the South Extension (76N). V. angularis can be associated with Rojdi A, C, and C/D strata.

Black gram is a dry land crop, planted in areas where rainfall is less than 85 cm annually on clayey or black cotton soils. It is usually sown during the monsoon season, or immediately after the rains in areas where rainfall is too heavy. Black gram is sown, harvested, processed and used in much the same way as green gram. Its yield also falls in a similar range. While V. angularis is cultivated in Gujarat, it is more popular in other regions of India. Today in Gujarat, more land is planted to green gram than black gram.

Nine carbonized seeds have been identified as being V. unguiculata, also known as horse gram or Dolichos biflorus. Confusion still exists over how to classify this species. There appears no consistency on this issue in the literature, regardless of the date of printing. What is referred to here as V. unguiculata is horse gram, a commonly cultivated pulse found throughout India. The seeds are all from the mid-upper

levels of trench 45K on the Main Mound and are associated with both Rojdi C and the Early Historic occupation. The seeds have a mean length of 3.92 mm and a breadth of about 2.38 mm. They were commonly flat, elliptic or reniform, and smooth. Although not always preserved, the hilum scar was thin and linear.

Horse gram is indigenous to South Asia, although today it is distributed throughout most of the tropical regions of the Old World. Its a popular dry-land crop in most regions of India, including Gujarat. Horse gram grows on any type of soil, including poor ones, and is considered a hardy drought-resistant plant. It is usually grown after the close of the rainy season. After sowing it takes between four to six months to mature. If it is grown as a fodder it is harvested around six weeks after planting. The yield after threshing and winnowing is within the range of the other species of Vigna. It is usually harvested between October and November, although in different regions it is planted in other seasons, and in some regions it is grown at several times a year. Grains of horse gram are processed and used in the same ways as green gram and black gram.

The remaining 22 seeds could not be speciated and were placed in the general category Vigna sp. Many of these seeds were well carbonized, and some were fractured. All but one of these seeds were from the mid-upper strata of the Main Mound. The one remaining seed was from the mid levels of 76N

on the South Extension. Again, like all remains of this genus, they are usually associated with either Rojdi C or Early historic occupation. The density of this genus never exceeded two seeds per liter of soil, and averaged one seed per liters soil.

Zizyphus. (Rhamnaceae). Eighty-nine fruits or seeds belonging to the species Zizyphus mauritiana (jujube) were recovered from four Rojdi trenches (only eight soil samples). All but three of the remains of Z. mauritiana were from the South Extension (the remaining three were from two trenches on the Main Mound). Remains come from Rojdi A, B, and C/D strata. 94 percent of the remains are from one strata and within one trench (76N), representing Rojdi A.

Seventy two of the recovered remains were fruitstones or fragments of fruitstones. They appear roundish with a rugose surface and a mean diameter of about 6.83 mm. All the fruitstones were carbonized and most were broken. Seventeen carbonized seeds of Indian jujube were also recovered. The seeds are more or less circular, flat, planoconvex with a minute point at the apex and a mean diameter of about 3.54 mm. Most of the seeds and fruitstones were found together, with a maximum density of 11 seeds or fruitstone fragments per liter soil.

This small evergreen tree can be seen growing today throughout India, including Gujarat, in both a cultivated and

a wild state. It grows in a variety of habitats including dry regions, and on most soils including sandy, black cotton or moderately saline soils. When cultivated, it can be grown by sowing seeds or transplanting seedlings. Planting and harvesting differ depending on region and variety, but in general, it is generally collected between February and March (Kajale 1987:85-86). The fruits are eaten fresh, dried, candied, stewed or smoked and are considered to have high nutritional value. The fruits serve as a good food substitute in times of scarcity or when the monsoon fails. The leaves provide a good fodder for cattle and goats during the summer. The bark of the tree is sometimes used for tanning and it has numerous medicinal applications. The wood is used in tools and for building purposes. In all, Zizyphus mauritiana is a plant of many uses, whether it is cultivated or collected in the wild. The origin of the plant is in Asia, possibly South Asia.

CHAPTER VIII. PALEOETHNOBOTANICAL RECONSTRUCTION AT ROJDI

As stated in the introduction, a series of questions were asked about Rojdi which the analysis of the archaeobotanical remains were intended to answer. It is believed that the answers will enable the construction of a Rojdi plant use/subsistence model (Chapter IX), which in turn can be used in conjunction with evidence from other sites for the construction of regional models of subsistence and plant use strategies (Chapter X). Since Rojdi has a number of distinct periods of occupation (A, B, C, C/D) the initial questions have been rewritten so that each period could be discussed independently. In considering the phases in turn, the common elements of all phases are interpreted in terms of general patterns of plant usage, while the differences between each occupation indicate changes in the Rojdi-plant interrelationship over time. Three categories of questions are most relevant to the understanding of plant occurrences in Rojdi occupations:

1. What plants were recovered, do they represent cultivated varieties and are they significant archaeologically?
2. What was the habitat like during the occupation?
3. What was the plant use strategy and what does this suggest about the occupation and subsistence?

In the pages that follow, interpretation of plant finds from each phase of occupation will conform to the structure of these three questions. Afterwards, a summary, and analysis of the common elements among, and differences between Rojdi A, B, C and C/D will be presented. All taxa identified from each occupation will be discussed, even material that may represent recent contamination or be from less secure proveniences. This has been done so that the reader can evaluate all the data, and because recent material may eventually be shown to be old and less secure material may become secure.

Rojdi A

The earliest occupation of Rojdi has been labelled "Rojdi A." This occupation level, as discussed earlier (Chapter V), was defined on the basis of ceramic analysis and radiocarbon dates. The occupation spans less than 200 years and dates to between 2500 and 2300 B.C. Since only a small portion of the excavation of Rojdi is represented by Rojdi A material, the botanical remains recovered during excavation of this occupation are also limited. The archaeobotanical material representing Rojdi A was recovered from only three trenches, one from the South Extension (76N), and two from the Main Mound (45K and 46L). Ceramic analysis for Trenches 46L and 76N has been completed, so that plant material from

these trenches can be securely placed in Rojdi A. While the ceramics from 45K are only preliminarily sorted, the strata thought to be Rojdi A show all signs of being such. In support of this conclusion, there is the trench's close proximity to 46L, which contains identifiable Rojdi A strata which continue into 45K.

From the three trenches, a total of 1742 seeds were collected from 280 liters of floated soil (table 16). The 74 samples analyzed from this occupation represent about sixteen percent of the Rojdi samples or about eleven percent of the floated sediments. While the majority of the soil and samples are from 45K, most of the seeds (85 percent) are from 46L and 76N suggesting a much higher seed density in these other trenches. Part of the reason for this is that the Rojdi A material in 45K (which is presently secure enough to label Rojdi A) is limited to the area from the "bins" to the platform base on which Rojdi was constructed. This limited area was heavily sampled in order to try to help determine the function of the bins, yet, unfortunately, few seeds were recovered. By contrast, the material from 76N is associated with trash heaps while samples from 46L are from occupational surfaces, pits and hearths. The proveniences of the samples within these trenches represents a variety of features including floors, hearths, bins, trash, burials, and pit fill (table 17), and therefore a range of interpretations can be made regarding the archaeobotanical material.

Table 16. Distribution of Rojdi A samples, soil and seeds.

	Stratum	No. of Samples	Vol. of Soil	No. of Seeds	No. of Taxa	Samples Without Seeds
Main Mound 46L	10-24	27	72L	704	16	6
Main Mound 45K	10-15	36	153	235	17	5
South Extension 76L	7-9	11	65	802	18	2
Total Rojdi A	-	74	280	1742	22	13
Percent of all Rojdi	-	16	11	12	26	18

Table 17. Types of Rojdi A samples.

Sample Provenience	No. of Samples	Number of Seeds	Liters of Soil	Samples with no Seeds
floor/surface	5	23	6.5	2
hearth fill	2	2	6	0
bins	21	164	83.5	4
pit fill	5	36	29	0
trash	10	223	61	4
general fill	11	556	30	2
soil column	17	717	52	1
burial	2	12	9	0
ash lens	1	9	3	0
TOTAL	74	1742	280	13

1. Plants Recovered. The 1742 seeds recovered from Rojdi A strata represent less than 13 percent of the archaeobotanical material from Rojdi, but nearly all the remains were carbonized and from secure archaeological proveniences suggesting they were deposited during the time

of occupation (figure 20). Twenty-four different taxa have been identified from Rojdi A (table 18).

Table 18. Material recovered from Rojdi A by taxa, with seed counts, percent of Rojdi A material, seeds per liter soil (density), and percent of samples (ubiquity).

Taxa	Number	Percent	Density	Ubiquity
Borreria	2	.1	.007	3
Cheno-Ams	4	.2	.014	4
Chenopodium album	59	3.4	.21	18
Cyperus	2	.1	.007	3
Dactyloctenium	8	.4	.03	7
Desmodium	36	2.1	.13	3
Digera muricata	3	.19	.01	1
Eleusine coracana	1083	62.01	13.86	31
Euphorbia prostrata	7	.4	.02	5
Ficus	10	.6	.03	5
Hordeum	10	.6	.03	4
Indigofera	7	.4	.02	5
Melilotus	4	.2	.014	3
Panicum sp.	15	.8	.05	7
Panicum miliare	215	12.1	.77	32
Setaria tomentosa	3	.19	.03	4
Setaria glauca	10	.6	.04	7
Setaria italica	12	.8	.04	10
Setaria sp.	3	.19	.02	4
Sida	1	.06	.003	1
Trianthema decandra	19	1.1	.05	18
Trianthema trequetra	2	.1	.02	3
Vigna	1	.06	.003	1
Zizyphus	78	4.4	.28	4
Unidentifiable	148	8.4	.53	63
TOTAL	1742	100 %	-	-

While 78 percent of the remains from Rojdi A are grasses, which are common food grains as well as fodder, they are also common weeds found in cultivated fields and could have been collected unintentionally. Less than one percent

of the Rojdi A seeds are thought to represent recent contamination, the lowest of any Rojdi occupation. While the remaining seeds were deposited during the occupation, their occurrence does not necessarily imply actual use or intentional collection by the Rojdi inhabitants. Even though all the plants identified as occurring in Rojdi A could have been used by humans (based on ethnographic analogy), it would be wrong to state their that occurrence necessarily represents such use. The following discussion of the plant material will be presented in order of importance, based on either the numbers of seeds recovered or its likely use as a crop plant. Of the Rojdi A material, Hordeum vulgare (barley), Eleusine coracana (finger millet), Panicum miliare (little millet) and Zizyphus mauritiana (jujube), are all commonly used and cultivated in South Asia today and are the most likely candidates for possible food crops of the occupants of this phase of occupation. Therefore the discussion will begin with these taxa which together account for nearly 80 percent of the identifable remains from Rojdi A.

Of these four species, barley was one of the more unexpected, yet significant botanical finds at Rojdi. In all, ten seeds were recovered from secure proveniences, eight seeds from within the trash layers 76N, and two seeds from an occupation surface in 46L (table 19). Barley was a common cultigen during the third millennium B.C. in many parts of

the world including the Indus Valley. Since the occurrence of a wild variety of barley in Gujarat at this time period is unlikely, its presence in the Rojdi record almost surely suggests that the occupants during Rojdi A occupation had access to cultigens.

Table 19. Distribution of Rojdi A taxa by trench and stratum. Only taxa with more than 20 seeds are included.

	76N		45K					
TAXA	7&8	9	10	11	12	13	14	15
C. album	1	-	7	-	-	-	-	1
Desmodium	-	-	-	-	-	34	2	-
E. coracana	554	-	16	-	-	3	-	15
P. miliare	115	-	14	-	-	-	5	1
Setaria	1	-	10	-	-	-	-	8
Trianthema	-	-	7	-	-	-	-	8
Zizyphus	78	-	-	-	-	-	-	-
other	17	-	19	4	-	-	-	24
unknown	37	-	37	4	-	-	1	15
total	803	0	110	8	0	37	8	72
samples	10	1	19	2	1	3	2	9
vol. soil	46	19	72	4	3	9	5	49

	46L														
TAXA	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
C. album	-	1	2	28	-	15	2	-	1	-	-	-	-	1	-
Desmodium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E. coracana	-	-	8	459	-	-	3	-	7	7	-	-	-	10	1
P. miliare	-	5	15	28	-	4	-	-	1	1	-	-	1	23	2
Setaria	-	-	-	2	-	1	-	-	-	2	1	-	2	1	-
Trianthema	-	-	-	1	-	1	1	-	1	-	-	-	-	2	-
Zizyphus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
other	-	1	-	-	-	2	2	-	1	1	-	-	1	2	-
unknown	-	-	8	14	-	11	3	3	2	6	-	-	2	1	4
total	0	7	33	532	0	34	11	3	13	17	1	0	6	40	7
samples	0	1	1	3	0	2	3	1	2	4	2	0	1	6	1
vol. soil	0	3	3	11	0	6	7	3	5	12	3	0	3	14	3

Its importance in the Rojdi diet and whether it was being grown locally are important questions. First, let us consider its possible importance in the Rojdi A diet. While the percentage of barley grains is small, less than one percent, its density could be considered high based on comparison to some of the other Rojdi A material (table 18). Yet its relatively high density is still low in comparison to other possible crop plants, for example, E. coracana. In the two samples containing barley, it represented less than 10 percent of the total plant remains. This, combined with the fact that only 10 seeds were recovered which could be identified as barley make it extremely difficult to suggest that barley was ever a major contributor to the diet at Rojdi. But it should be noted that the samples at this level of occupation were small and it is possible that larger deposits of barley grains would have been uncovered if more excavation of Rojdi A strata were attempted.

The next question regarding barley is how these seeds got into the Rojdi A deposits. Was it being grown locally, or were the occupants of Rojdi in this period consumers, and not producers of barley? Because it is generally grown in cold weather conditions, it is rarely cultivated in Gujarat today, where the preference is for crops that are well adapted to a summer monsoon weather pattern or dry winter conditions. If one assumes that the weather pattern was not that different during the Rojdi A occupation from today, (as

the data seems to imply), then barley would not have been a favored crop. A dearth of additional information, for example, weed seeds associated with barley cultivation, or straw nodes and chaff often associated with the harvesting and processing of barley, suggests that it is unlikely that barley was being cultivated at the site, or if it was, it was not being done to any great extent. The presence of *Hordeum vulgare* at Rojdi some 4500 years ago is significant in that it shows that the settlers of Rojdi were in possession of a domesticated cereal grain which is not indigenous to Gujarat. It implies either direct or indirect contact with people further to the north. Furthermore, it shows that the early occupants of Rojdi had access to the major plant domesticates of the Harappans, yet these never became the dominant food resources of the Rojdi occupants. And, finally, there is also the suggestion that whoever initially settled at Rojdi came with grains of barley, possibly from the north where barley was a common cereal grain.

Of all the plants represented in Rojdi A strata, none occurred as regularly, and at such high densities and percentages, as *Eleusine coracana* (finger millet or ragi). As is seen in tables 18 and 19, ragi is found in nearly a third of the Rojdi A samples, adding up to slightly over 62 percent of all the botanical material recovered from this phase of occupation. Seeds were recovered from floors, pits, bins, fill and trash, always in a carbonized state and always

in association with concentrations of charcoal. Based on present theories regarding non-indigenous origins (Weber 1987), it is unlikely that wild E. coracana was ever growing in Gujarat, and since these seeds appear morphologically similar to cultivated varieties of ragi found in India today, it is likely that these archaeological seeds found in Rojdi A represent a cultivated variety of Eleusine sp.

The presence of ragi in almost every conceivable circumstance, and at times in high concentrations, implies ragi was readily available and commonly used. In samples where ragi was present, it accounted for, on average, 77 percent of the botanical material, and in a number of cases it made up closer to 90 percent of the seeds. This implies that at some point the seeds of ragi were separated from other material, (weed or other unwanted seeds), so that a relatively pure grain was available for use. The only other seed that appears in high frequency in samples containing ragi is P. miliare. At this time, it is unknown whether the occurrence of these seeds together represent mixing at times of cultivation, processing, or use.

Although no chaff or other portions of the Eleusine plant have been identified, all indications point to local cultivation. The high concentration of Eleusine seeds, their diverse locations within the site, indicate that the Rojdi occupants were cultivating ragi by the earliest periods of occupation. While E. coracana was most likely being used

as a cereal grain, it is also probable that it was being used as a fodder. Some carbonized seeds may therefore be the result of the burning of dung, but because of the occurrence of nearly pure, high densities of ragi on occupation surfaces, the most logical explanation for its occurrence in Rojdi A is as a food for human consumption.

If ragi was being grown locally (as seems to have been the case), based on the actions of contemporary cultivators of this cereal grain, it would have been planted during the summer monsoon season and grown with the minimum of human management, with neither irrigation nor manuring being needed (see Chapter VII). After a fall harvest, it could be stored for up to 50 years prior to use. Its hardiness to inconsistent moisture patterns, and even drought, meant that it was a reliable crop during most years. Besides being nutritionally valuable to humans, it also made a good fodder. This is chiefly speculation, since no real data exist regarding actual activities or attitudes toward E. coracana at Rojdi. Since no uncarbonized remains of this species have been found, which is more likely due to preservation factors rather than sample size, and since seed grains usually get burned by accident and not intentionally, (excepting the case of burned dung) (Miller and Smart 1984), it is difficult to determine specific activities regarding its use. Ragi could easily have been carbonized through such simple actions as spillage during boiling.

While nowhere near the same number of grains of _Panicum miliare_ were recovered as _E. coracana_, they did make up the second largest percentage of Rojdi A seeds (12 percent). This small millet, which is probably indigenous to South Asia, was observed in more samples than any other plants from this occupation. Its density was not always high, although in some Rojdi A strata it did reach levels of over 27 seeds per liter soil (high compared to the nearly 6 seeds per liter soil average for Rojdi A). Because of its common occurrence on floors, in trash and in the general fill itself, and due to its significant density at many of these locations, _P. miliare_ was most likely being intentionally brought into the site. Since this plant can be found growing in a wild state throughout this region, as well as being cultivated, it is difficult to determine if these seeds at Rojdi are from a cultivated crop. While we lack direct evidence to conclude that either cultivation or collection of _P. miliare_ as a wild plant was going on, several facts are illuminating. For example, we can assume that Rojdi A occupants had access to domesticated plants, and probably did practice cultivation. Since _Panicum miliare_ was often found in samples with cultigens (mainly _E. coracana_), and since this small millet needs even less management than ragi, and like ragi grows well in summer rainfed conditions, in all likelihood some cultivation, or at least human management of _P. miliare_ probably took place at Rojdi. If not cultivation, then

surely intensive collection of wild stands was occurring, for the counts and density of _P. miliare_ are too high to explain in any other manner. _P. miliare_'s distribution throughout the site implies it was readily available, and if its status as a food grain was as low then as it is now, it is unlikely that the Rojdi inhabitants would have been prepared to make exchanges for it. Local acquisition and use thus seems the most likely possibility.

While _P. miliare_ is generally planted during the summer monsoon, it can, and often is, grown throughout the year. Because it needs less water than any other millet, it is especially well suited to environments where moisture is undependable. Since it is also used as a fodder, its occurrence in Rojdi as a carbonized seed could be as a result of dung being used as a fuel. Yet its presence in a carbonized state, and at times in high concentrations, helps support the argument that this species was being grown or collected primarily for its use as food for humans, and used secondarily for fodder. Since _P. miliare_ is processed like ragi, its carbonization may have occurred during similar activities (e.g. boiling).

The occurrence of _P. miliare_ shows that non-African millets were being used in South Asia some 4500 years ago. This fact is important to remember in later discussions when the origins, movements, and significance of millets in South

Asia during the second and third millennium B.C. are considered (see: Chapter VIII and IX).

The last of the four possible crop plants of Rojdi A is Zizyphus mauritiana (jujube). The carbonized seeds and fruits identified as Z. mauritiana were all recovered from a single sample in the lowest level of 76N. This species is commonly cultivated throughout Gujarat today, although there is no evidence that these remains were collected from cultivated trees during the Rojdi occupation. Since the remains were all recovered from one sample within a trash midden, their uses, or the activities causing their carbonization, are virtually impossible to discern. However, the lack of samples containing this species suggests that either there is a sample bias, or the importance or actual use of jujube (Z. mauritiana) was minimal. For this reason, it is most likely that it was not being cultivated, but rather collected in the wild.

A number of the remaining taxa occur at either interesting locations with relatively high densities, or their mere presence has intriguing implications. As a group, these remaining taxa represent 19 different categories of plants (excluding those that could not be identified), yet only account for 208 seeds, or 12 percent of the total remains from Rojdi A (table 18). Nearly half of these remains represent either Chenopodium album (59 seeds) or Desmodium sp. (26 seeds).

Seeds of C. album were recovered from 18 percent of the Rojdi A samples, accounting for three and a half percent of the botanical remains. Their density was never particularly high (0.8 per liter soil), and the seeds accounted for generally a small percentage of the total seed count in a given sample (table 18). Since this herb is a common weed in disturbed soils, it may represent nothing more than unintentional contamination that occurred during the Rojdi A occupation. However, its significant role in later phases of occupation implies that we take its occurrence in Rojdi A to be the result of deposition during the phase itself. While C. album may not have been cultivated at Rojdi, it could have easily have been collected during the spring, either as a seed grain or as a vegetable source of leaves and stems.

All thirty-six seeds of Desmodium sp. were mineralized, badly decayed and found in association with the "bins" in 45K. Since their actual species could not be identified, it is difficult to understand their presence. Since they represent the only mineralized seeds recovered at Rojdi, it might be that what caused their mineralization is associated with the function of these features. Based on the data presently available, it would be premature to speculate further.

Another 51 seeds, or three percent of the Rojdi A seeds, can be categorized as a group of grasses (Dactyloctenium

aegyptium, Panicum sp., and Setaria sp.), which grow well in the area and are at times cultivated. They are also commonly found in cultivated fields as weeds. The simple presence of these seeds is worth noting, but since they are commonly found in the region and were never recovered in large numbers with either a high density or ubiquity, it is difficult to discuss their importance during the Rojdi A occupation. Several of these grasses appear with greater frequency in later phases of occupation, and in proportions and densities which are significant. Like Chenopodium album, their limited occurrence in earlier levels becomes significant retrospectively, when changes in the Rojdi plant record are examined.

Besides these grasses, a number of other plant species were identified which may represent weeds. These include Trianthema decandra, Trianthema trequetra, Euphorbia prostrata, Digera muricata and plants in the Cheno-Am category. Many of the seeds in these five categories were not carbonized and may well represent recent contamination. None of these species were found in significant numbers or densities, and their total percentage was less than two.

One seed of Vigna angularis (black gram) was recovered from a lower stratum of 76N. This carbonized seed was recovered from a trash area and not from an occupational surface. This popular dry land crop, which is commonly grown during the summer monsoon, is an important cultigen in India

today. Since only one seed was recovered, it is hard to determine if its presence is due to it being cultivated, collected in the wild, being brought in from somewhere else, or is due to contamination from other periods of occupation. If its presence is associated with Rojdi A, then it represents one of the earliest find of this species in the archaeological record for South Asia. At this time, its occurrence in Rojdi A should only be looked upon as tentative, until either the seed is dated itself, or other sites from the time period also yield Vigna angularis.

The remaining six plant taxa from Rojdi A, which include Borreria sp., Cyperus sp., Ficus sp., Indigofera sp., Melilotus sp., and Sida sp., could not be identified beyond genus level. Since these remains total only 26 seeds (one and a half percent of Rojdi A botanical material), little can be said regarding their occurrence in the Rojdi A record. Their density and ubiquity is never high, and they always occur in a sample with a large mixture of seeds. Interestingly, they were not evenly distributed throughout Rojdi A trenches, but were mostly recovered from 45K. Of the 1742 botanical remains from Rojdi A, 148 were unidentifiable (table 18 and 19). Almost all of these were carbonized and some were fragmented as well. As can be seen in table 19, their numbers were equally divided between the three Rojdi A trenches, yet their density in 46L and 76N was twice that of 45K. This corresponds well with seed densities in

general, where 45K also had the fewest identifiable seeds. All samples from Rojdi A had charcoal. Although the weight and volume of the charcoal varied depending on the provenience of the sample, this variation does not appear significant and its range was narrow. A sample representing each type of pottery was examined for organic temper. All the thicker, cruder wares had plant parts used as temper, while the finer wares contained no such material. The only identifiable species was that of Setaria sp. While most of the organic material was stems, a few seeds could be seen and identified.

Upon examination of the strata in 46L, a pattern of two different groupings of plant taxa becomes apparent. The analysis of the ceramics from this trench showed a slight change in the Rojdi A ceramics, leading to the division of the Rojdi occupation into A1 and A2. In Trench 46L, Strata 10 through 16 have been identified as Rojdi A2, and Strata 17 through 24 as A1. An independent but corresponding distinction, marked by different percentages and densities of seed remains among the plant species, was also found in these strata (table 20). While many more seeds were recovered in A2, the overwhelming majority of them were E. coracana (76 percent) with a density rate of over 15 seeds per liter soil. No barley is found in A2 and the remaining taxa can be divided into three categories of nearly equal percent and density, C. album (48 seeds), P. miliare (52

seeds), and other (47 seeds). In Rojdi A2, the signifant plant taxa based on percentage, density and ubiquity, is E. coracana.

Table 20. Differences in taxa counts (numbers of seeds, percent and density) between Rojdi A1 and Rojdi A2 in Trench 46L.

TAXA	A-1 stratum No.	%	seeds/L	A-2 stratum No.	%	seeds/L
Chenopodium album	2	2	.05	48	8	1.6
Hordeum sp.	2	2	.05	0	-	-
Eleusine coracana	25	29	.6	470	76	15.6
Panicum miliare	28	32	.7	52	8	1.7
Other	30	34	.7	47	8	1.6

By contrast, Rojdi A1 (the earliest occupation at the site), no species dominates. E. coracana and P. miliare appear in nearly equal percentages and densities, and C. album's occurrence is negligible. Hordeum sp. appears but in a low percentage and density. The remaining species account for slightly less than 35 percent of those in A1, in comparison to eight percent in A2. In sum, A1 has a greater variety of plants than A2, with no dominant species.

Since this division in Rojdi A can only be detected in one trench, these patterns may the result of a limited sample, although both Rojdi A1 and A2 in Trench 46L were associated with occupational surfaces. Yet, as will become

apparent as the discussion continues, many of these plants become important later at Rojdi and therefore should not be ignored in these early strata.

2. **Habitat.** All of the plants identified in Rojdi A samples except two genera (Hordeum sp. and Melilotus sp.), commonly occur in Gujarat today, and grow well in hot or warm, dry environments with only moderate amounts of moisture, usually monsoon derived. The occurrence of species common to both Rojdi A and the present day implies that there has been no dramatic change in climate since the time period of Rojdi A. However, some differences in Rojdi A climatic and environmental conditions can be detected. Although they may be skewed due to human activities, counts in arboreal pollen are slightly higher in the Rojdi A samples from the trash midden than in the surface level of the site, implying greater tree cover during the period of Rojdi A occupation. Further, pollen analysis of Rajasthan lake beds (Singh et al. 1974) suggests that the climate was wetter at the time corresponding to Rojdi A. Preliminary analysis of the pollen from Rojdi A suggests the existence of slightly cooler and wetter conditions, although easily within the range of what would be needed for most of the taxa to grow. On the other hand, we should note that the remarkable variability of rainfall levels from year to year presently seen in Gujarat

(see Chapter IV) may well subsume the level of moisture indicated by prehistoric pollen.

In sum, Rojdi climate over the past few thousand years may best be conceived of as encompassing a range of conditions without substantial deviation from a pattern of light summer monsoon rains and dry winters. The Rojdi inhabitants' choice of plants reflects this pattern of unpredictability within overall consistency. Plants that survive in an archaeological site like Rojdi are generally those that are useful to humans as a food source, fuel or fodder, and plants that have the most plasticity with regard to environmental requirements are also the ones humans exploit. Moreover, there is no single season during which all these plants produce seeds. While the majority are found today growing during the summer monsoon, a number of species flower in the spring (table 21). The overall impression is of a site in which food procurement activities took place year round (figure 22). Yet, since the majority of the seeds are from plants which produce these seeds during the summer and fall, cultivating activities were probably focused on the summer monsoon system.

Table 21. Summary of information about possible crop plants found in Rojdi A soil.

TAXA	Harvest Season	Percent	Density	Purity	Ubiquity
Chenopodium album	Spring	3.4	0.21	5	18
Eleusine coracana	Monsoon/ Fall	62.0	3.86	77	33
Hordeum sp.	Winter/ Spring	0.6	0.03	9	2
Panicum miliare	Monsoon/ all-year	12.0	0.77	18	34
Setaria sp.	Monsoon/ Fall	1.6	0.09	19	12
Zizyphus sp.	Spring	3.0	0.28	39	1

Figure 22. Likely Rojdi A annual farming activities.

```
               Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr
May
----------------------------------------------------------
Plowing        ----- - - -
Sowing           - - ----- - - -
Management
(hoe-weeding)            - - - - -
Harvest         - - - -------------- - -
Processing                  - - --------------- - - - -
Grazing
(in fields)                - - ------- - -
Dispersed
 grazing       - - - - - - - -        - - - - - - - - - - -
Tending
 livestock     --------------------------------------------
Wild plant
collection    ---------------------------------------------
```

3. Plant-Use Strategies. The integration of these botanical remains, their numbers, percentages, densities, and proveniences, with other artifactual and structural information about the Rojdi A occupation, leads to several conclusions about the settlement, its subsistence system and its relation to the localized resource catchment. Based on the seasonality of the plants, the presence of crop plants, domesticated animals, and a range of artifactual and structural features, Rojdi A appears to be a permanently occupied site, with its own, independent subsistence base. Acknowledging Rojdi A was a food-producing settlement, with subsistence activities going on in and around the site, and throughout the year (tables 20 and 21), models can be constructed which show the possible relationships the inhabitants might have had toward their subsistence base. Attempting to incorporate the production unit, the consumption unit, the territory being exploited, and the flow of energy into a single demonstration of this relationship, three possible models seem to fit the Rojdi data.

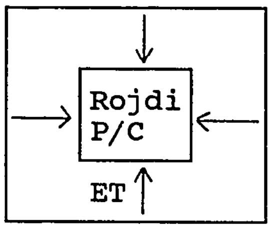
As shown in figure 23, these models attempt to depict schematically the types of subsistence system which could have occurred during the Rojdi A occupation. Either Rojdi represents a closed community, where the inhabitants produced and consumed all that they needed in the vicinity of the site (Model A); or Rojdi was part of a larger settlement system, with this site being the permanent settlement and with

smaller, outlying, seasonally occupied farming settlements, herding communities, or satellite units consisting of local transhument groups, contributing to their subsistence system (Model B); or, the third possibility, Rojdi consisted of individual production and consumption units rather than the communally-organized system posited in the previous two models (Model C). This last model is suggested because at this time the size of these units cannot be determined, nor whether they consist of a number of fairly independent subsistence units, (households or family units), or a communally-organized system, where there would have been joint effort in production within the settlement as a whole, with shared consumption of the products.

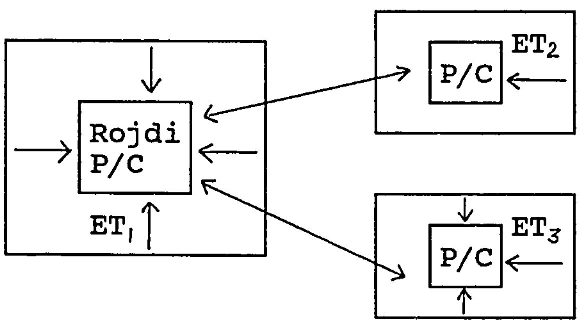
A fourth option, not suggested in figure 23, is that Rojdi was part of a larger settlement system, dependent on other sites to which it supplied foods, or alternately, from which it derived its own food. The reason this was not considered was that there is little indication that Rojdi was involved in plant exchange, and since all the species being exploited were so well suited to the local habitat (with the exception of barley), and required such minimal levels of human involvement to obtain a reasonable yield, it is most reasonable to assume that they were being produced locally.

Figure 23. Rojdi A occupation's relation to its subsistence base (the concepts underlying the construction of this model are derived from Thomas 1983:292).

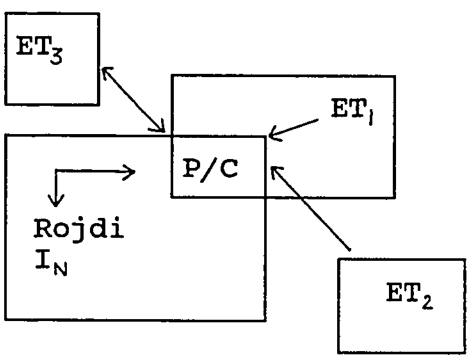
A.



B.



C.



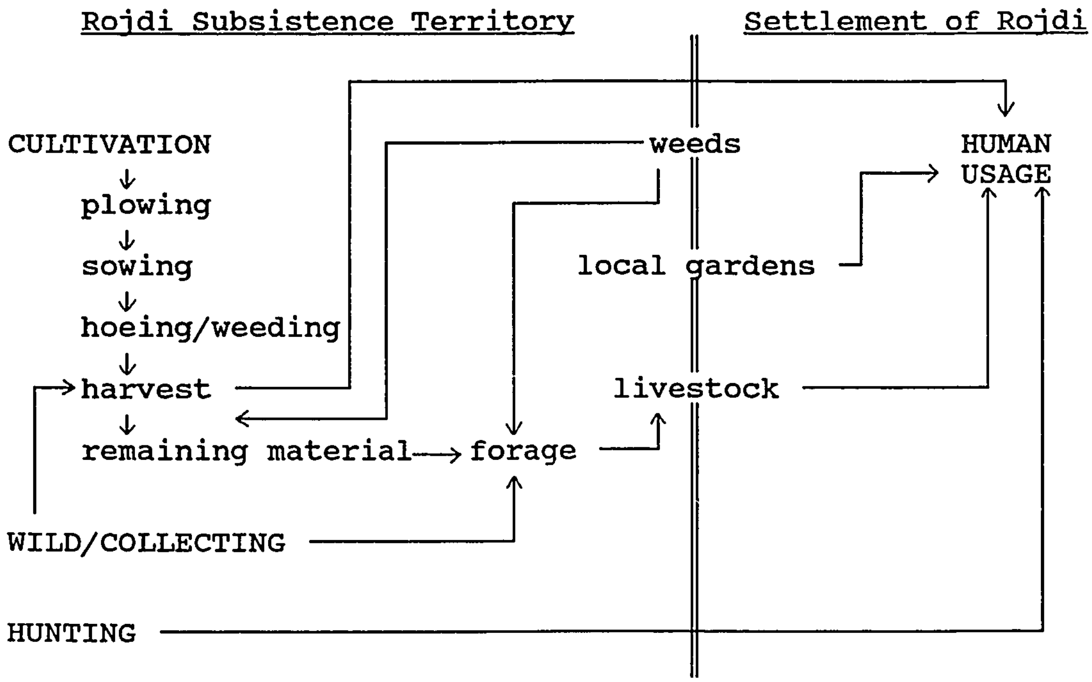
P - production unit ET - exploited territory
C - consumption unit I - individual production/consumption unit
---> flow of energy

Extreme caution should be exercised when interpreting village farming practices and their subsistence territory in any prehistoric South Asian context, since such variables as

population size, social structure, and territorial boundaries are unknown or difficult to discern from archaeological contexts. Therefore, it may be better to view the subsistence territory of Rojdi A as a set of variables involving environmental opportunities and limitations. In other words, understanding the territory being exploited may be best performed through the reconstruction of subsistence activities and actual resources recovered. In this way, a subsistence territory is defined by four different activities, (cultivation, wild plant collecting, animal husbandry, and hunting), each exploiting the resources in the region and leaving some residue in the archaeological record. Viewing Rojdi and its subsistence territory as separate but interacting entities, a model can be constructed which shows the types of subsistence activities occurring at Rojdi and where these activities could have taken place (figure 24).

Since the boundaries of the Rojdi subsistence system are unknown, quantifying output, production or consumption is difficult if not impossible. Furthermore, the subsistence system was by no means a completely closed system. For these reasons, there is no way to quantify the relative importance of pastoralism versus cultivation versus hunting and gathering activities. To understand resource-use decisions at Rojdi, we must comprehend the environmental context of the site, the occupant's perception of their world, their daily activities, their options and their adaptive strategy. Their

Figure 24. Rojdi A subsistence activities and their territory.



subsistence system is a product of their history -- a history of evolution, improvisation and innovative responses. In other words, while the habitat around Rojdi limits and influences their subsistence strategy, it is actually a result of a complex set of decisions involving the evaluation of many different factors in the light of a variety of goals. Since so little is known about their own system (e.g. behavior, the spatial distribution of people and resources, the types and efficiency of their procurement system and their technology and scheduling), or influences from other

systems or peoples, to suggest decision-making strategies or calculate energy flow models for Rojdi would be premature.

Both the type of cultivation probably being practiced and the type of plants being collected appear to be well suited to a monsoon-oriented subsistence system needing a minimal amount of organized management. The animal husbandry at Rojdi, probably focusing on cattle, most likely involved a larger territory than the plant economy. Until the completion of the analysis of the faunal material, it would be inappropriate to make suggestions regarding the territorial needs of Rojdi herds, except that it probably required some movement of cattle to various regions depending on season. If dung was being used as fuel, as it is often used today, then the range of carbonized remains should give some indication of the habitats these cattle were exploiting. Since over 99 percent of the Rojdi plant remains could be found in the immediate vicinity of Rojdi, there is no indication that the movements of cattle were to habitats that different from the one around Rojdi, or if cattle were taken to regions with different habitats, no plant material from these locations made it back to Rojdi. As is expressed in figure 24, remains from cultivating, and hunting and gathering, are generally found in the subsistence territory, while the remains from livestock may be part of both the subsistence territory and the settlement itself.

Rojdi A Summary. Twenty four different categories of plants have been identified with a total seed count of 1742. Most are carbonized, and were recovered at proveniences implying their deposition during the Rojdi A occupation. It appears that both cultivated and wild plants were being used at this time, with a greater dependence on cultivated plants. Rojdi A seems to have been occupied year-round, with cultivation and various pastoral activities being practiced locally. Indications are that the major growing season was based on the summer monsoon and a minimal amount of activity went into the management of these crops. From the beginning of the occupation, plant and animal domestication is evident. There is no evidence for either the need or the presence of irrigation, and there appears to be reliance on the summer monsoon. Finally, the habitat during the occupation was not that different from today's, other than the possibility of slightly wetter weather and and/or more tree coverage.

ROJDI B

Botanically, Rojdi B strata appear different from both A and C in terms of species present and their counts, density, and ubiquity. Yet, B does share characteristics with Rojdi A and C that correspond to its status as a transitional phase. However, as will become apparent, based on common botanical elements, Rojdi B may in many ways be

better understood as an extension of Rojdi A. In this connection, it should be noted that there is no break in the Rojdi occupation, in that there appears to be a continued deposit of sediment associated with human occupation.

For all three periods of occupation, deciding which trenches and strata to associate with which occupation is a difficult process, especially since the analysis of the ceramics at the time of writing was not complete. For this reason, a number of different criteria were used to decide which strata to call Rojdi B. This mainly involved the use of trenches for which the ceramic analysis had been performed, and associating their strata, walls or features with trenches where ceramic analysis is still lacking. After completion of the ceramic analysis there may be a need to re-categorize some of the botanical remains from Rojdi B.

Nonetheless, this process of extending strata, floors, walls and other features in order to make use of all the botanical data may not be that misleading, in that the differences in percentage, ubiquity and density of the major plant groups differ only slightly between those strata which are definitely Rojdi B (only trenches where ceramic analysis has been completed), and those that are possibly Rojdi B (trenches where ceramic analysis has not been completed, but where strata could be associated to those trenches where ceramic analysis has been completed). Only two trenches, 46L and 76N, fit the first category while three trenches fit the

latter, (45K, 76L and 76H). Of the 1724 seeds associated with the Rojdi B occupation, slightly more than half (960 seeds), can definitely be assigned to this occupation. Since distributions among the botanical remains differ so slightly between those possibly associated and definitely associated with Rojdi B, the following discussion will focus on all likely Rojdi B material.

Three hundred and seventy two liters of soil were floated from these five trenches, representing 59 samples or 13 percent of the total Rojdi samples (table 22). The two trenches on the Main Mound yielded most of the samples (69 percent), soil (70 percent) and seeds (94 percent). The remaining three trenches with Rojdi B botanical remains were on the South Extension. While other regions of the site may well represent Rojdi B, such as the lowest levels of the large square building in the North Slope area, or the circular structures below the rock walls on the South Extension, either these areas were not sampled or no remains were recovered from them. The plant identification and distribution patterns observed in strata five through nine of Trench 46L basically hold true for all the material labeled as Rojdi B.

Table 22. Distribution of Rojdi B samples, soil and seeds.

	Stratum	No. of Samples	Vol. of Soil	No. of Seeds	No. of Taxa	Samples Without Seeds
Main Mound 46L	5-9	12	62	620	17	2
Main Mound 45K	5-9	29	200	1001	26	2
South Extension 76N	6	2	14	17	2	1
South Extension 76L	6	14	86	85	16	0
South Extension 76H	6	2	10	1	1	1
Total Rojdi B	-	59	372	1724	31	6
Percent of all Rojdi	-	13	15	12	32	8

1. Plants Recovered. A total of 31 different categories of plants were identified (table 23). They were from samples collected from a variety of locations including possible floors, pot interiors, pits or other features, trash deposits, ash lens, or general fill (table 24). Ten samples were from soil columns from three different trenches (45K, 46L and 76N). Five hundred and forty two seeds or 31 percent of the total botanical material recovered from Rojdi B strata represent recent contamination. Most noticeable were 339 grains of Euphorbia prostrata which accounted for over 60 percent of the recent material or 19 percent of the total Rojdi B seeds. Since almost all these seeds (98 percent) were from only two samples from the same trench (45K), they may well represent some form of contamination due to the burrowing of a rodent or insect. Therefore, all material from these samples should be looked upon as questionable.

Most interestingly, another 190 seeds representing unidentifiable material were also recent and from the same two samples. Less than five percent of material which is thought to be recent, (based on their uncarbonized and fresh appearance), was found in samples other than these two in 45K. Since few carbonized seeds were recovered in these samples, the impact on the overall interpretation of the material deposited during the Rojdi B occupation is minimal. Even when these samples are disregarded, the presence of five percent recent contamination is still a significant increase from the Rojdi A, where less than one percent was observed.

Of the identifiable seeds which were probably deposited during the occupation of the Rojdi B phase, three species account for 76 percent (table 26). These three species, goosefoot (Chenopodium album), ragi (Eleusine coracana), and little millet (Panicum miliare), were all present in the preceding occupation (Rojdi A) and seem to have continued to play an important role in the subsistence activities of this occupation (tables 25 and 26). However, their percentages, ubiquities and densities significantly shift from one phase of occupation to another. The most interesting of these shifts is that found occurring with C. album.

Table 23. Material recovered from Rojdi B by taxa, with seed counts, percent of Rojdi B material, seeds per liter soil (density), percent of samples (ubiquity) and percent carbonized.

Taxa	Number	Percent	Density	Ubiquity	Percent Carbonized
Abelmoschus*	4	0.02	0.01	5	0
Brassica*	1	0.05	0.002	2	100
Cheno-Ams	4	0.2	0.01	5	53
Chenopodium album	556	32.25	1.5	20	100
Chloris*	5	0.3	0.01	5	0
Corchorus*	17	1.0	0.005	3	23
Cyperus	3	0.1	0.01	5	81
Dactyloctenium	11	0.6	0.03	12	39
Digera muricata	8	0.4	0.02	8	15
Eleusine coracana	98	5.68	0.263	39	100
Euphorbia granulata*	10	0.6	0.01	5	2
Euphorbia prostrata	339	19.66	0.93	8	1
Ficus	3	0.1	0.01	5	38
Fimbristylis tenera*	4	0.2	0.01	5	100
Indigofera	4	0.2	0.01	5	11
Lotus*	1	0.05	0.002	2	100
Melilotus	3	0.10	0.01	2	100
Panicum miliare	251	14.56	0.69	41	100
Panicum sp.	15	0.8	0.04	8	89
Phyllanthus fraternus*	3	0.1	0.01	5	0
Saccharum*	3	0.1	0.01	5	0
Scirpus*	1	0.05	0.002	2	100
Setaria tomentosa	5	0.3	0.005	8	75
Setaria glauca	2	0.1	0.005	3	50
Setaria italica	15	1.0	0.04	16	75
Solanum*	3	0.1	0.005	5	33
Tragus*	2	0.1	0.005	3	0
Trianthema decandra	54	3.1	0.14	40	31
Trianthema trequetra	8	0.4	0.02	12	30
Zizyphus	2	0.1	0.005	3	100
Unidentifiable	289	16.7	0.78	81	65
TOTAL/AVG	1724	100	4.6	100	69
Recent contamination	542	31	1.4	46	-

* not found in earlier levels of Rojdi

Table 24. Types of Rojdi B samples.

Sample Provenience	No. of Samples	No. of Seeds	Liters of Soil	Samples with no Seeds	No. of Carb. Seeds
floor/surface	1	5	2	0	5
pot interior	2	5	6	1	5
pit fill	7	428	24	1	428
trash	20	125	93	2	112
general fill	15	835	175	2	414
soil column	10	95	29	0	79
ash lens	4	231	43	0	222
TOTAL	59	1724	372	6	1182

Table 25. Distribution of Rojdi B taxa by trench and stratum. Only taxa with more than 20 seeds are included.

Taxa	45K 5	45K 6	45K 7	45K 8	45K 9	76N 6
C. album	1	1	-	-	51	15
E. coracana	5	35	-	17	8	1
Euphorbia	1	-	-	131	201	-
P. miliare	7	46	-	24	152	-
Setaria	1	3	-	7	5	-
Trianthema	12	8	-	14	-	-
other	7	3	-	32	8	-
unknown	9	35	-	172	5	1
total	43	131	0	397	430	17
samples	5	7	0	11	6	2
liters of soil	35	46	0	63	56	14

Table 25 (continued).

Taxa	46L					76L	78H
	5	6	7	8	9	6	6
<u>C. album</u>	-	1	-	2	476	9	-
<u>E. coracana</u>	-	2	-	-	33	7	-
<u>Euphorbia</u>	2	6	-	-	3	5	-
<u>P. miliare</u>	1	-	-	-	21	-	-
<u>Setaria</u>	-	-	-	-	1	5	-
<u>Trianthema</u>	4	1	-	-	6	17	-
other	1	16	-	-	13	15	-
unknown	3	-	-	2	36	27	1
total	11	26	0	4	579	85	1
samples	4	1	0	1	6	14	2
liters of soil	19	3	0	3	37	86	10

The greatest number of seeds belonging to any single species (556 seeds) and with the highest average rate of seeds per liter soil (2.02) in Rojdi B were those of <u>C. album</u>. Further, the samples with <u>C. album</u> had few other seeds so that on the average the taxa made up 86 percent of the seeds in samples with <u>C. album</u>. While this species has a long history of use by humans in many regions of the world, there is little documentation for its presence in archaeological sites within South Asia. Yet the dominant appearance of <u>C. album</u> in Rojdi B is hard to ignore. Most of the grains were from one stratum (9) in Trench 46L, within an ashy layer of soil (table 25). The density of seeds of this species within this stratum reached a level of nearly eight seeds per liter soil with few other seeds being

present. C. album often accounted for over 90 percent of the seeds in samples from this area. This high count and density was basically only associated with this one stratum, for few seeds of C. album were observed above or below Stratum 9. Furthermore, while the seeds were often carbonized, many were not. Due to the large volume of C. album seeds and their density, it is difficult to imagine how their presence could be anything other than intentional collection.

C. album is a common herb found growing in the wild throughout Gujarat today, most often in disturbed soils. In South Asia, the greens are often collected and eaten while the seeds are less commonly consumed, although there are a number of ethnographic references to such practices (Weber 1987). While small amounts of carbonized seeds of this species would conform to a model of some collection of this wild growing plant for human consumption, or its accidental introduction into Rojdi as a weed, (as maybe the case with Rojdi A), the higher densities and counts found in B cannot be explained in the same way.

Interestingly, the seeds of C. album can not only be processed and consumed like millets, but they grow in much the same way. They produce many small seeds per head, they grow in a variety of soils, and they are a very hardy plant needing little human involvement for a reasonable yield. Is it possible that C. album was looked upon as a cereal grain in much the same way as many of the millets? While there is

Table 26. Differing counts concerning security (provenience/contamination) for possible crop plants found in Rojdi B soil.

	Eleusine	P.miliare	C.album	Setaria	Other	Tot.
All material 372 liter soil 59 samples						
Numbers	98	251	556	22	797	1724
Percents	6	15	32	1	46	100
Avg. density	0.26	0.69	1.5	0.06	2.1	-
Ubiquity	39	41	20	22	84	-
Archaeobotanical material only 372 liter soil 59 samples						
Numbers	98	251	556	22	255	1724
Percents	8	21	47	2	22	100
Avg. density	0.26	0.69	1.5	0.06	0.68	-
Ubiquity	39	41	20	22	76	-
Archaebotanical material from secure proveniences only 195 liter soil 31 samples						
Numbers	51	198	545	12	154	960
Percents	5	21	57	1	16	100
Avg. density	0.29	1.02	2.8	0.06	0.79	-
Ubiquity	58	57	32	25	77	-

no indication that this plant was being cultivated, there is every reason to believe that it was being intensively collected in relatively large numbers, separated or sorted from other material and used in some way in which at least some of the grains could become carbonized. Still, the question arises as to why this change in attitude toward C.

album should have come about. In contrast to the millets, C. album would be generally harvested in the spring, a time of year when the summer millet consumption could be running low. A particularly bad harvest from the previous fall could have led to the need to exploit other less favorable resources like C. album. Further, if a plant was needed in times of scarcity, it should not be surprising that it resembles the preferred, cultivated varieties in many of its characteristics.

The most important plant of Rojdi A, and one which is also commonly found in Rojdi B stratum, is E. coracana. Ragi accounted for eight percent of the non-recent botanical material recovered in Rojdi B and was a common find in trash, on floors, in features and in the general fill (tables 23 and 25). It had an average density of about 0.49 grains per liter soil and ubiquity of 39 percent. While these numbers are substantially down from those in Rojdi A, they are still relatively high compared to the figures of other plant species in this phase of occupation, and imply that ragi was probably still being cultivated. Yet, while the percentage of samples with E. coracana remained about the same, the drop in density from a 10.05 average to a 0.49 average accompanied with a drop in purity from 77 percent to 15 percent suggest that ragi cultivation was being done in lesser amounts and in association with other, mostly weed taxa. While it is possible that a sampling bias or some taphonomic process has

occurred which can account for this change, it is more plausible that it reflects some alteration in usage of E. coracana. What could have induced such a change in the use of a species which was not only the most common plant of the previous occupation but one which was well-suited to the environment and probably the socio-economic system as well?

Little millet, P. miliare, was also found to occur at a lower density in Rojdi B than in Rojdi A. Yet in contrast to E. coracana, P. miliare actually increases in terms of the number of seeds retrieved, and in terms of its percentage of Rojdi B material. Further confusing the interpretation of this millet is that while there is a slight increase in the percentage of samples with this seed, (from 34 to 41 percent), there is a slight decrease in its purity rate (from 16 to 18 percent). In sum, while P. miliare is still commonly occurring during the Rojdi B occupation, the grains are more spread out in the soil matrix and appear more like a weed than an intensely cultivated plant. Its density, purity rate and the percentage are more similar to E. coracana in this phase than than they were in Rojdi A.

In contrast to the other millets (P. miliare and E. coracana), Setaria sp. occurs at nearly the same rate in both Rojdi A and B. There is little difference in the percentage, density, and purity rates, or in the percent of samples found with this grain. Setaria sp. occurrences still imply only minor usage or accidental intrusion as a weed. On the other

hand, all measures of _Zizyphus_ sp. decline relative to their high counts and densities though low ubiquity in Rojdi A.

Of the remaining taxa occurring in Rojdi B, which add up to less than 22 percent of the non-recent seeds, no single species represented more than five percent of the total (table 23). Three taxa (_Desmodium_ sp., _Hordeum_ sp. and _Sida_ sp.), which were represented in Rojdi A, though totalling less than three percent of the botanical material recovered during that occupation, were not found in strata associated with Rojdi B. On the other hand, twelve taxa occur in Rojdi B which were not observed in A. Yet only five species (_Brassica_ sp. _Corchorus_ sp., _Lotus_ sp., _Scirpus sp_ and _Solanum_ sp.) are archaeologically relevant since seven of the taxa (_Abelmoschus_ sp., _Chloris_ sp., _E. granulata_, _F. tenira_, _P. fraternus_, _Saccharum_ sp. and _Tragus_ sp.) represent recent material. Therefore only three percent of the non-recent botanical material observed in Rojdi B represents taxa which were not found in the previous occupation. Since these five archaeologically deposited taxa could not be identified to the species level, and since they make up such a small percentage of the Rojdi B material, further analysis of their occurrence and significance will not be carried out at this time. In all, a greater amount and variety of botanical material thought to be recent contaminate the soil matrix of Rojdi B than in A.

Weed seeds also increase in percent and density in Rojdi B. One species of particular interest is _Trianthema decandra_, which was the most prominent weed plant found in Rojdi B strata. This aggressive weed was found in one third of the samples and accounted for nearly five percent of the Rojdi B seeds. With an average density of 0.3 seeds per liter soil it occurs at double the density with which it occurred in Rojdi A. The percentage of seeds and percentage of samples with this taxa increase at an even greater rate. _T. decandra_, a plant of little use to humans that commonly grows in cultivated fields, trash areas, or on ground disturbed by either human activities or by natural causes (e.g. flooding). Its dramatic increase indicates that soil disturbance around the site increased.

2. Habitat. In general, however, the habitat in and around the site during the Rojdi B occupation was probably not that different from that of Rojdi A. The same types of plants appear in the macrobotanical record. The pollen record, though still preliminary, shows a slight decrease in arboreal pollen. The introduction of only a few new species, the lack of any real change in the pollen record, and changing plant proportions taking place among those species that grow in very similar conditions, all lead to the conclusion that there is unlikely to have been any real change in the local climate, although there are indications of increasing land

disturbance and possibly deforestation. However, the striking occurrence of C. album could indicate a short, severe climatic shift taking place in the course of the Rojdi B occupation.

3. Plant-Use Strategies. Just as Rojdi A2 is an extension of a pattern seen in A1, Rojdi B appears in many ways like an extension of A, including the same plants, with a few taxa changing in terms of their percentages and densities. If these changes are not the result of a sample bias due either to too small a sample, or due to the differing locations of the samples, then it is fair to assume that some aspects of the subsistence system were changing. However, as with the changes in the ceramics, these are not major and the material from Rojdi B strata still resemble A more than C.

The changes in density, ubiquity, and percentage of seeds from Rojdi A to B show a minor shift in plants that were mainly dependent on the summer monsoon to ones that grow well year-round or ones which can be harvested in the spring. There is also a shift away from plants which are definitely cultigens and are not indigenous to Gujarat to indigenous plants which could have been found growing wild (e.g. P. miliare, C. album and many of the pulses). The remaining changes include a decrease in the density and amount of charcoal and an increase in weed seeds, as well as a slight increase in the number of different taxa represented. While

specific plant usages may be evolving or changing, the overall strategies of subsistence at Rojdi, based on cultivation and animal husbandry, as well as plant collecting and hunting, seem to have remained the same.

Rojdi B Summary. The 1724 seeds from Rojdi B strata represent 30 different identifiable categories of plants, with slightly more than 68 percent at proveniences and in conditions implying association with this occupation. Cultivated and wild plants are present in numbers that imply a subsistence strategy incorporating both activities. Rojdi B represents a continuation of Rojdi A, featuring a year-round occupation, where cultivation and pastoralism were both practiced locally. Summer monsoon-oriented cultivation most likely continued to be the pre-eminent strategy of the inhabitants of the Rojdi B phase. However, the evidence for summer monsoon-oriented cultivation is not as good in Rojdi B as it was in Rojdi A, and while there is still no indication of irrigation, there are a number of shifts in plant occurrences implying a lessened reliance on the summer monsoon moisture pattern. The habitat was still within the range of what can be found in Gujarat today, although disturbance may have increased from Rojdi A, and tree-cover may have decreased.

ROJDI C

The occupation phase most exposed through excavation was Rojdi C. Since there is no stratigraphic break between Rojdi A, B, or C, the starting date for Rojdi C is not firmly fixed. It began at around 2000 B.C. and lasted for about 200 years. Since the upper levels of Rojdi C were close to the surface it was not possible to get an accurate C^{14} date, so that the actual date of abandonment was not precisely determined either.

As with the previous Rojdi occupation, assigning trenches and strata to specific Rojdi phases is difficult due to the incomplete state of the ceramic analysis. Based on preliminary ceramic analysis, all upper strata of the South Extension trenches belong to Rojdi C, the upper mid-levels of the trenches in the North Area of the site, including the large square building and some of the upper strata of the main mound trenches, are also classified as Rojdi C. Due to the early historic occupation (Rojdi D) on the main mound and the subsequent mixing of strata in the upper four strata of 45K and the upper three strata of 46L, a separate discussion will be presented, following this one, on the Rojdi C/D mixed samples.

The botanical material from Rojdi C was examined at three levels. First, all the material from likely Rojdi C strata was grouped together and examined. Then the large

percentage of material representing recent contamination (due to its close proximity to the surface), was removed so that only archaeologically deposited material remained for further analysis. Finally, only that material which could be associated with the Rojdi C occupation with some degree of certainty was analyzed. At each stage, quantitative operations on the archaeologically relevant data yielded highly similar densities and ratios. In addition, the observed pattern and simple occurrence of plant remains in trenches definitely associated with Rojdi C (46L Stratum 4, and 76N Strata 1-5) changed little with the addition of material from trenches where the ceramic analysis has yet to be finalized, although a preliminary analysis does suggest a Rojdi C association. When the analysis of Rojdi C ceramics is completed, an updating of the botanical remains may be in order, and minor interpretations may change. However, it is considered unlikely that the overall subsistence reconstruction would be affected significantly.

Because the initial phase of the excavation at Rojdi produced a considerable amount of horizontal exposure, and since at most locations Rojdi C represents the final occupation of the site (except in the Main Mound area), a high percentage of samples associated with this occupation are near the surface. The result is that nearly 60 percent of the botanical remains (4880 seeds or other plant parts), are thought to be fairly recent and represent contamination.

Besides these uncarbonized, recent seeds, seeds were found in low numbers with few documented uses, so that their usefulness in subsistence reconstruction is minimal. Finally, if the unidentifiable remains and seeds whose provenience in Rojdi C strata is doubtful are included, nearly 70 percent of the botanical material from this occupation is of dubious value. While this is a large percentage, the remaining, archaeologically significant material from Rojdi C still outstrips the quantity (in number of seeds) from either Rojdi A or B. Archaeologically deposited floral material from Rojdi C accounts for 41 percent of the total for the site as a whole.

Due to the large number of analyzed samples associated with Rojdi C (284 samples), and their wide distribution throughout the site, it makes more sense to discuss the material by its general location (North Slope, Main Mound, South Extension), and by type of sample (e.g. fill, column, burial, trench, hearth, sherd concentration) rather than by trench and stratum (32 trenches representing a total of 87 strata (tables 27 and 28).

Table 27. Distribution of Rojdi C samples, soil and seeds.

	No. of Samples	Vol. of Soil	No. of Seeds	No. of Taxa	Samples Without Seeds
North Slope	59	365	2521	43	7
Main Mound	36	175	461	34	4
South Extension	189	1019	5232	55	37
Total Rojdi C	284	1559	8214	59	48
Percent of all Rojdi	62	63	57	67	68

Table 28. Types of Rojdi C samples.

Sample Provenience	No. of Samples	No. of Seeds	Liters of Soil	Samples with no Seeds	No. of Carb. Seeds
floor/surface	3	96	33	0	93
pot interior	36	107	238	15	93
pit fill	18	182	173	3	151
trash	25	646	157	0	47
general fill	146	3151	665	27	1863
soil column	8	81	33	1	62
surface/ stratum 1	37	3353	199	0	348
burial	2	10	13	0	10
hearth	1	0	0.1	1	0
sherd concentration	8	588	48	1	227
TOTAL	284	8214	1559.1	48	3334

Sixty two percent of the samples collected for flotation at Rojdi are associated with Rojdi C. Of these samples, 59 were from the north area with 365 liters soil, 36 were from the Main Mound with 175 liters of soil, leaving the largest

amount from the South Extension with 189 samples and 1019 liters of soil (table 27). The seeds recovered were equally distributed with most coming from the South Extension (5232 seeds), followed by the North Slope (2521) and lastly, the Main Mound (46L).

i. Plants Recovered. Sixty categories of plants have been identified from material associated with Rojdi C (table 29).

Twenty-nine of the 60 categories were not found in earlier Rojdi occupations. Of these new taxa, 14 are due to recent contamination and therefore have limited significance, leaving 15 archaeologically deposited taxa that were recovered in neither A nor B. By contrast, only four taxa that are found in either A or B, were not recovered in C. While the marked increase in new species is a distinctive feature of the Rojdi C occupation, it is the striking changes in the proportions of existing plants that are most informative about this phase. The following discussion of the Rojdi C archaeobotanical remains will focus on three categories, the possible crop plants, then the common weeds, and finally the exotics, or plants with low numbers but with intriguing implications.

Table 29. Material recovered from Rojdi C by taxa, with seed counts, percentage of Rojdi C material, seeds per liter soil (density), percent of samples (ubiquity) and percent carbonized.

Taxa	Number	Percent	Density	Ubiquity	Percent Carbonized
Abelmoschus	7	0.08	0.004	2	0
Boerhavia diffusa*	35	0.4	0.022	5	0
Borreria*	17	0.2	0.011	5	100
Brassica	1	0.01	0.0006	0.3	100
Carex*	261	3.2	0.167	8	0
Cenchrus*	40	0.4	0.026	4	0
Cheno-Ams	28	0.3	0.018	5	51
Chenopodium album	75	0.8	0.048	6	100
Chloris	281	3.4	0.18	29	0
Convolvulus*	2	0.02	0.001	0.3	100
Corchorus	11	0.1	0.007	1	22
Cucumis*	4	0.04	0.003	1	34
Cyperus	31	0.4	0.019	6	87
Dactyloctenium	274	3.4	0.176	21	40
Digera muricata	775	9.4	0.497	29	15
Digitaria*	56	0.7	0.036	8	0
Echinochloa*	12	0.1	0.008	2	100
Eleusine coracana	95	1.1	0.06	7	100
Elyonrus*	17	0.2	0.01	2	0
Euphorbia granulata	163	2.0	0.1	18	5
Euphorbia prostrata	238	3.0	0.152	16	5
Euphorbia thymifolia*	191	2.3	0.122	10	5
Ficus	42	0.4	0.027	2	39
Fimbristylis tenera	12	0.1	0.008	0.3	100
Glossocardia*	14	0.1	0.009	2	0
Goniogyna*	61	0.8	0.039	3	0
Impatiens*	6	0.08	0.004	1	0
Indigofera	165	2.0	0.106	16	10
Ipomoea*	2	0.02	0.001	0.3	100
Lathyrus*	2	0.02	0.001	0.3	100
Lens*	3	0.02	0.001	0.3	100
Linum*	1	0.01	0.0006	0.3	100
Melilotus	13	0.1	0.008	1	100
Melochia*	5	0.06	0.003	1	15
Neptunia*	4	0.04	0.003	0.3	100
Panicum miliare	76	0.8	0.048	7	100
Panicum sp.	90	1.1	0.058	14	95
Paspalum*	4	0.04	0.003	1	0
Peltophorum*	10	0.1	0.006	2	0
Phyllanthus	70	0.7	0.045	6	100
Polygala*	1	0.19	0.0006	0.3	0
Polygonum*	6	0.07	0.004	1	100

Table 29. (continued)

Taxa	Number	Percent	Density	Ubiquity	Percent Carbonized
Rorippa*	4	0.04	0.003	1	0
Saccharum	299	3.6	0.192	24	0
Sapindus*	1	0.01	0.0006	0.3	0
Scirpus	1	0.01	0.0006	0.3	100
Setaria tomentosa	107	1.3	0.068	15	100
Setaria glauca	579	7.0	0.371	23	71
Setaria italica	708	8.6	0.459	35	72
Setaria sp.	95	1.1	0.061	3	69
Solanum	49	0.5	0.031	8	40
Sorghum*	24	0.2	0.015	1	100
Stellaria	12	0.1	0.006	2	72
Tragus	143	1.7	0.92	14	0
Trianthema decandra	1813	22.0	1.163	60	32
Trianthema trequetra	189	2.3	0.121	19	31
Trianthema portulacastrum*	7	0.08	0.004	2	30
Verbascum*	30	0.3	0.02	5	0
Vicia*	1	0.01	0.0006	0.3	100
Vigna radiatus*	1	0.01	0.0006	0.3	100
Vigna sp.*	1	0.01	0.0006	0.3	100
Unidentifiable	952	11.6	0.61	51.0	72
TOTAL/AVG	8214	100.0	-	-	-
Recent contamination	4880	59.0	0.75	-	-

* not found in earlier levels of Rojdi.

Thirteen taxa were identified from Rojdi C material which are commonly used today in Gujarat, or were recovered in significant amounts in A or B suggesting usage in the past. These include, Brassica, Chenopodium album, Dactyloctenium aegyptium, Echinochloa, Eleusine, Lathyrus, Linum, Lens, Panicum miliare, Panicum, Sorghum, Setaria, and

Vigna. Eleusine coracana, Panicum miliare, and Chenopodium album, the major seeds in Rojdi A and B, appear at numbers (percentage, ubiquity, and density) below those from the previous occupations, yet still at rates of occurrence implying some form of usage (tables 29 and 30). The presence of carbonized grains of each species on occupation surfaces, and in densities of nearly one seed per three liters of soil suggest that uses of these plants may have decreased but not disappeared.

One taxa which was recovered in Rojdi A and B in relatively low numbers and which becomes the dominant plant in Rojdi C, is Setaria. Three species of Setaria (Setaria tomentosa, Setaria glauca, and Setaria italica) have been preliminarily identified (refer to Chapter VIII) as occurring in Rojdi C. In total, they represent slightly over 30 percent of the plant remains deposited during Rojdi C.

Prior to Rojdi C, Setaria never totaled more than five percent of the seeds. This significant change shows up in all forms of quantification, from density and ubiquity to levels of purity, and percentage of remains. The Setaria sp. were generally split between Setaria glauca and Setaria italica. The two species were also found mixed together in the same sample. While Setaria seeds were recovered in all three areas of the site, the majority were from the north area and the south extension, the areas where most of the samples representing Rojdi C, were collected.

Over one third of the Setaria glauca and Setaria italica seeds were from below sherd concentrations (possibly representing storage vessels). Many of these grains were not carbonized, suggesting their possible deposition more recently than the Rojdi C occupation. Yet, samples above these sherd concentrations contained few seeds of Setaria, supporting the belief that their presence is indeed related to the deposition of these Harappan-like sherds. With a higher density below the sherd concentration than above, it is difficult to explain the presence of Setaria in this context as being any other than a prehistoric occurrence, unless some sort of reverse stratigraphy took place. Since no historical material was observed in these concentrations, the possibility of reverse stratigraphy is an unlikely one. Corroborating evidence for this conclusion can be found on the Main Mound, where carbonized seeds from secure proveniences have been identified as Setaria sp., and in numbers significantly above those from the previous levels. Thus, the view that these uncarbonized grains, associated with sherd concentrations, were also deposited during the Rojdi C occupation does not seem to be in the least contradictory. We still need to explain how uncarbonized seeds could have preserved so well, and for so long, in the Rojdi soil. If immediate burial of these grains took place, so they were not exposed to the elements, and if they

Table 30. Differing counts concerning security (provenience/contamination) for possible crop plants and other plants occurring in significant numbers in Rojdi C.

	All material				All Archaeobotanical material				Secure Archaebotanical material			
Liters of soil	1559				1559				958			
No. of samples	284				284				179			
TAXA	No	Pe	Ub	De	No	Pe	Ub	De	No	Pe	Ub	De
<u>C. album</u>	75	1	6	0.5	75	2.5	6	0.02	60	3	8	0.06
<u>E. coracana</u>	95	1	7	0.06	95	3.0	7	0.06	81	3	10	0.09
<u>P. miliare</u>	76	1	7	0.05	76	2.5	7	0.05	63	3	11	0.07
<u>Setaria</u>	1489	18	42	0.95	1042	31.0	42	0.68	895	33	56	1.0
<u>Sorghum</u>	24	0.3	1	0.02	24	1.0	1	0.02	24	1	1	0.03
<u>D. aegytium</u>	274	3	21	0.18	109	3.0	11	0.07	30	1	6	0.03
<u>D. muricata</u>	775	9	29	0.50	116	3.0	6	0.07	70	3	11	0.07
<u>Trianthema</u>	2009	24	63	1.30	613	18.0	47	0.40	481	18	28	0.50
<u>Euphorbia</u>	592	7	29	0.38	48	2.0	3	0.03	31	1	5	0.03
Unknown	952	12	51	0.61	665	20.0	44	0.43	489	18	50	0.50
Other	1853	23	92	1.19	471	14.0	91	0.30	467	16	87	0.49
Total	8214				3334				2691			

No - Number of seeds
Pe - Percent of Rojdi C material
Ub - Ubiquity (percent of Rojdi C samples)
De - Density (seeds per liter soil)

remained in an undisturbed and protected manner around large numbers of sherds, or enclosed in pots, then it may be possible to explain their unusual preservation. Besides being the only major cereal grain from Rojdi C, many of the *Setaria* sp. grains were found in spikelets with rachis attached. Also, mixed with these grains were a few fragments of light chaff (broken lemma, glumes, etc.). This implies that partially-cleaned spikelets of *Setaria* sp. were being brought into Rojdi either for storage purposes or for further processing within the site. In either case, it supports the view that both *Setaria italica* and *Setaria glauca* were being grown locally. Furthermore, the relatively high purity rate suggests that some preliminary sorting of this material had already been performed prior to its deposition within Rojdi (especially those samples associated with the sherd concentrations).

Setaria is generally a summer sown plant which grows well during the monsoon rains, yet it can be planted and grown throughout the year. While *Setaria glauca* needs almost no human involvement or management after planting, *Setaria italica* is often weeded after sowing. A further difference between these two species is that while both are useful fodders, *Setaria italica* is rarely fed to cows since it tends to induce abortion or reduce the secretion of milk (Government of India 1972:304-312). Since *Setaria italica* represents nearly 50 percent of the *Setaria* seeds and has a

consistently high density throughout Rojdi C, an interesting question arises as to the relation of the Rojdi C inhabitants to cattle. Does this represent a change in animal usage or does it solely reflect a shift in food grains for human consumption? Until the analysis of the faunal assemblage at Rojdi is complete, the answer to this question will remain unknown.

An increased usage of a grass like Setaria could occur for many reasons, including natural changes in temperature, watertable and rainfall, human-induced depletion of minerals in soil, or deforestation and subsequent erosion, and finally a variety of cultural reasons, for example a desire for higher yields, different nutritional needs, changes in taste, preference or values, or socioeconomic decisions regarding levels of human management or exchange. Whatever the cause, Setaria sp. became a prominent crop plant in Rojdi C. While its place of origin may be highly debated, (being in East Asia or South Asia), its appearance in archaeological sites in South Asia between the second and third millennium B.C. is a common and accepted occurrence (Rao et al. 1987; Weber 1989; Savithri and Vishnu-Mittre 1978).

Besides the unidentifiable species of Setaria and Panicum (different from those species which were identified and discussed), three other cereal grasses were also identified which may have been obtained through cultivation or wild collection, Dactyloctenium aegyptium, Echinochloa and

Sorghum While Dactyloctenium aegyptium occurred in low numbers in both Rojdi A and B, Echinochloa and Sorghum were not observed in samples from either Rojdi A or B.

Seeds of Dactyloctenium aegytium increased from less than one percent of the sample in Rojdi A and B to about three percent in Rojdi C. Further, it increases in average density over five times. While D. aegytium occurs in nearly the same percentage of samples in all three occupations, there is a slight increase in its purity rate in Rojdi C. What these numbers suggest is that D. aegyptium is occurring at a higher frequency and in higher numbers during the Rojdi C phase. While this species is used and sometimes even grown in South Asia, it is also a common weed found in cultivated fields. Since D. aegyptium was often found in samples with Setaria, it may have been an aggressive weed growing in Setaria fields, possibly a plant that was allowed to grow in such a field since it ripens at a similar time and could itself be used as a cereal grain.

The twelve grains of Echinochloa sp. represented a small percentage of the material deposited during the Rojdi C occupation, and occurred in low densities. While a number of millets grown today in Gujarat are members of the Echinochloa genus, (i.e. barnyard or sawa millet), it also contains grasses which commonly grow as weeds in cultivated fields. At present, the low numbers of Echinochloa sp. in Rojdi C seem to support the possibility that it is a weed.

Sorghum is the last of the millets occurring in Rojdi C. Its occurrence during this occupation places it in India at a date earlier than previously thought. While only 24 seeds were recovered, they had a high average density rating of over one seed per liter soil that places *Sorghum* in the top 10 percent of the food grains from Rojdi C. This relatively high density was mainly due to its occurrence in only two samples, both from secure proveniences, in Trench 46L on the Main Mound. Since so few grains were recovered, it cannot be determined at this time whether *Sorghum* was being cultivated locally or being brought in from some other place. *Sorghum bicolor*, a species which needs hot weather to grow well, is a common domesticate found throughout much of India today (due to the fact that it grows particularly well in regions with a summer monsoon pattern). Today, it is often cropped with *Setaria* and *Echinochloa*. While the presence of *S. bicolor* at Rojdi may have little significance in the local subsistence system, its appearance at Rojdi in a secure provenience is important in that it would seem to confirm the presence of this African crop plant in South Asia by the beginning of the second millennium B.C. The introduction of *Sorghum* into South Asia will be discussed further in the next chapter.

Finally, five remaining taxa (*Brassica*, *Lathyrus*, *Lens*, *Linum*, and *Vigna*) are all found in Rojdi C in low numbers but are common cultigens in Gujarat today. Whether their

occurrence at Rojdi indicates the beginning of deliberate collection or cultivation, or documents accidental inclusion of a wild species is unknown. The appearance of any one of these cultigens, which are all sown during the winter season, would by itself be a weak argument for the broadening of the subsistence base in Rojdi C. However, the occurrence of five such species together is far more suggestive of diversification in both farming strategies and plant material. On the other hand, since Rojdi C has been extensively sampled, and since these taxa were not represented in either large numbers, high densities or in many samples, it seems that, whether they were being collected or cultivated, they never amounted to a significant portion of the diet. Yet one cannot lose sight of the fact that it is possible, (though unlikely), that there is a sampling bias, or for some reason these taxa were not carbonized, or were not placed in situations where they would likely preserve.

Seeds of weed species are important for our understanding of sowing and harvesting practices, soil fertility patterns, as well as indicating the amount of disturbance in and around a site. Because samples of Rojdi C occupation are closer to the surface than A or B, and because of the large amount of horizontal exposure at the upper levels of the site, a large portion of the weed seeds are uncarbonized and may represent recent contamination.

Trianthema is the major weed seed deposited during the Rojdi C occupation, just as it was in the Rojdi B occupation. Other weed species occurring in Rojdi C are Euphorbia sp., Stellaria sp., Digera muricata, and possibly Dactyloctenium aegyptium. Even when only the carbonized weed seeds are tabulated, there is a marked increase in their numbers, density, ubiquity, and percentage, in comparison to the previous occupation. Seeds of these weedy species were recovered in nearly all the samples, with no real pattern appearing in regards to their location in the Rojdi C soil. The high density of weed seeds (an average of about 1.5 seeds per one liter of soil), associated with a high ubiquity (over 90 percent), represents a great deal of disturbance to the habitat. This could be due to natural causes, (e.g. flooding), or human causes (e.g. population growth, increased agriculture, increased herd size, deforestation, increased construction or land clearing).

Twenty nine taxa not found in previous Rojdi occupation phases were discovered. Of these, 14 are taxa which probably represent recent contamination, including: Boerhavia diffusa, Carex, Cenchrus, Digitaria adscendens, Elyonrus, Glossacardia, Goniogyma hirta, Impatiens, Paspalum scrobiculatum, Peltophorum, Polygala, Rorippa, Sapindus and Verbascum. Of the remaining, newly found taxa, 11 are represented by carbonized remains from secure proveniences (Borreria, Convolvulus, Echinochloa, Ipomoea, Lathyrus

sativus, Linum, Neptunia, Polygonum, Vicia, Vigna and Vigna radiatus), and four represent a mixture of carbonized and uncarbonized seeds from less secure proveniences (Cucumis, Euphorbia thymifaloia, Milachia and Trianthema portulacastrum). All twenty nine of these taxa together represented less than ten percent of the Rojdi C material.

Of the remaining taxa not yet mentioned from Rojdi C, five taxa were reoccurring recent contaminants (Abelmoschus, Chloris, Saccharrum, Scirpus, and Tragus), three taxa were represented by previously observed seeds which are only seen in a carbonized state (Fimbristylis tenera, Melilotus, P. fraternus), and 10 were previously identified plant categories containing a mixture of carbonized and uncarbonized seeds (Cheno-Ams, Corchrus, Cyperus, Dactyloctenium aegyptium, Digera muricata, Euphorbia, Ficus, Indigofera, Panicum and Solanum). Carbonized and uncarbonized remains were only grouped together in general tabulations (table 30). Whenever comparisons were made, only carbonized totals were contrasted with carbonized totals of a species. While these 18 plant taxa may amount to over 30 percent of the total Rojdi seeds, they represent less than 15 percent of the carbonized, securely provenienced material recovered in Rojdi C.

2. Habitat. Since changes in plant occurrences, or the presence of new species are often related to environmental

change, an examination of the Rojdi C habitat is in order. First, the increase in weedy species in association with a continued decrease in the volume of charcoal and in the percentage of arboreal pollen suggest that deforestation was occurring during the occupation of Rojdi. A number of new species (e.g. Sorghum) suggest a warmer or drier climate than had occurred previously. This does not mean that a substantial change in climate had taken place, since all the major food plants could tolerate such conditions. But a prolonged drought, a temporary change or decline in the monsoon, or a temporary warming trend, all common occurrences in Gujarat today, could provide the ideal setting for a particular plant, e.g. Sorghum, to flourish, while crops that prefer wetter conditions might perform less well in comparison.

3. Plant-Use Strategies. Due to the increase in the variety of plants, and with no single species attaining the density and dominance of Eleusine coracana and Chenopodium album observed in Rojdi A and B, reconstructing the plant based subsistence during the Rojdi C occupation is more complex than for preceding occupations. Not only does Rojdi C appear to be significantly different from Rojdi A and B, but it seems to be based on a greater variety of plants grown and harvested throughout the year. The focus of Rojdi C cultivation or plant-based dependence is upon two species of

Setaria, with some dependence on _E. coracana_ and _Panicum miliare_. _C. album_ may also have been used. Pulses, (e.g. _Vigna_, and _Lathyrus_, _Lens_) oil yielding plants (e.g. _Brassica_ and _Linum_), and additional millets (ie _Echinochloa_ and _Sorghum_) had all become part of the Rojdi C record (table 31). In Rojdi C, no single plant represents more than 35 percent of the recorded remains or has an average density greater than one seed per liter soil, a significant change from Rojdi A and B. Further, many of the plants which are found in Rojdi C were also found in A and B, but in considerably lower numbers.

Table 31. Summary of information about possible crop plants in Rojdi C (all computations based on secure archaebotanical material only).

Taxa	Harvest Season	Percent	Avg. Density	Ubiquity	Percent Pure
Brassica	Winter	0.05	0.001	0.5	50
C. album	Spring	2.5	0.018	8.0	12
D. aegyptium	Monsoon/ all year	3.0	0.07	6.0	4
Echinochloa	Summer	0.3	0.008	3.0	5
Eleusine	Monsoon/ Fall	3.0	0.061	10.0	19
Lathyrus	Winter	0.1	0.001	0.5	6
Linum	Summer/ Fall	0.05	0.001	0.5	33
P. miliare	Monsoon/ all year	2.5	0.048	11.0	22
Sorghum	Monsoon/ Fall	1.0	0.015	1.0	40
Setaria	Monsoon/ Fall	31.0	0.68	56.0	66
Vigna	Winter	0.1	0.001	1.0	5
Lens	Winter	0.1	0.001	1.0	5

Based on the location, condition and numbers of the main Rojdi C cereal grains (Eleusine coracana, Setaria italica, Panicum miliare and Sorghum bicolor), summer monsoon-based cultivation was probably being practiced during this occupation. While all four of these millets can be found in a cultivated state in Gujarat today, only P. miliare also appears as a wild grass. Although cultivation is generally associated with the summer monsoons, all four are at times cultivated in irrigated fields during other seasons of the year. The presence of Setaria in an uncarbonized state with glumes attached, and in high concentrations of over 50 grains per liter soil, suggests local storage of this species and probably local cultivation. None of the millets need excessive management in the forms of irrigation, manuring and weeding, though such action would increase yield.

Specific reconstruction of crop husbandry practices occurring during Rojdi C occupation is as difficult and speculative as it was for the previous occupations. While there is no real evidence regarding tilling methods, there is some evidence that sowing times were not limited to a single season of the year. The types of millets and pulses being used, in association with the weed species, suggest that sowing occurred both during the summer and the winter. While some weeding may have been practiced, the large number of weeds found with many of the cereal grains suggests that weeding was not being intensely carried out. The lack of

archaeological evidence for irrigation and the ease with which the cereal grains could be grown during the monsoon suggest that if irrigation was practiced, it is unlikely that it played a major role in cultivation practices during this time of year. If a winter harvest took place, as the data seems to suggest, then it is quite likely that some form of water management system was practiced due to the lack of winter moisture.

Only _Setaria_ seeds were found in association with glumes, nodes and other chaff material. The implication is that while _Setaria italica_. may have been threshed at the site after harvest, the other millets appear to have been threshed elsewhere. This may reflect the overall focus on _Setaria_ over the other millets, or may be simply due to some forms of sampling bias. The finds of _Eleusine coracana_, _Setaria italica_, _Panicum miliare_ and _Sorghum bicolor_ on occupational surfaces, in and around pits and specific features, or associated with sherd concentrations or whole vessels, supports arguments that their occurrence is associated with human usage. The assumption here is that useful plants, (cultivated or collected), will occur more frequently in association with cultural features than species merely tolerated or not actively encouraged (Matthews 1983:2-3). The continued presence of such species as _Chenopodium album_ and _P. miliare_, as well as other species of _Chenopodium_ and _Panicum_, suggest that wild species were still occurring

in significant quantities, implying that if they were not actively encouraged, they were tolerated or at least not discouraged. Wild plant collection appears to continue as an active part of the plant usage strategy during Rojdi C. Non-cultivated species account for about 15 percent of the identifiable carbonized seeds associated with well documented proveniences in cultural strata. Their usage is only speculative, since their carbonization and preservation in the Rojdi record could be a result of accidental inclusion, yet their consistent presence in significant densities does suggest purposeful use.

Assuming some usage of wild plants, the cultivation of millets and some pulses, and a dependence on livestock, a possible scheduling of annual activities regarding subsistence plants can be constructed. As can be seen in figure 25, plant-oriented activities would have been focused on the summer and fall, although it is quite possible they were spread throughout the year. The subsistence territory included cultivated land and ranges in which hunting, collecting and herding took place -- as described for Rojdi A (figure 24). Further, there is no evidence for any change in the way Rojdi C relates to its subsistence territory in terms of its production and consumption.

Rojdi C definitely shows signs of expansion not only in the variety of plants exploited, but in the settlement itself. Most of the construction of walls seen in the area

of the site referred to as the South Extension belongs to the Rojdi C occupation. Whether this reflects a growing population, or some other change in the settlement layout, is unknown at this time. Expansion of the site could explain the high density and ubiquity of disturbance plant taxa, and a low level of charcoal (in comparison to lower levels), although any type of major disturbance to the habitat could also cause this to occur.

Figure 25. Likely Rojdi C annual farming activities.

```
                Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr
May
-----------------------------------------------------------
Plowing         ----- - - -               - - - -
Sowing            - - ----- - - -             - - - - - -
Management
(hoe-weeding)         - - - - - - - -
Harvest          - - - -------------- - -     - - - - - - - -
Processing                  - - -------------- - - - - - - -
Grazing
(in fields)                - - ------- - -          - - - - -
Dispersed
 grazing        - - - - - - - -          - - - - - - - - - - -
Tending
 livestock      --------------------------------------------
Wild plant
 collection     --------------------------------------------
```

The upper levels of Rojdi C differ little from the lower levels, suggesting no change occurring during this phase of occupation. Further, the last levels prior to abandonment do not show differing amounts of seeds, nor, in general, any

signs of change. There is thus no indication of natural or cultural stress in the form of changing plant usage patterns prior to the abandonment of the site. If one were to accept the hypothesis that people would first try to adapt to, for example, an environmental stress (e.g. drought, flood) by their choices of plants, (either by altering cultivation practices or through trade), rather than move to another area, then some indication of such a strategy should appear. Therefore, although this is to use negative evidence, it appears that Rojdi was abandoned for reasons other than progressive environmental stress.

Rojdi C Summary. While 8214 seeds were recovered from Rojdi C strata, only 2691 are from secure proveniences and represent material definitely deposited during this occupation. Although cultivated plants make up the bulk of the recovered material, remains representing wild species suggest their collection and use continued. There is every indication that the site was occupied throughout the year, with seasonal activities involving cultivation and herding. Both summer and winter cultivation was probably being practiced, with indications that Setaria italica was being brought into the site prior to threshing. A number of different plant taxa were being used at the site which suggest a focus on the summer monsoon season with a secondary dependence on winter cultivation. The appearance of new

plants non-indigenous to South Asia implies the continued existence of interactional spheres involving Rojdi with peoples outside the region. Other than an increase in local disturbance to the natural habitat, possibly including deforestation, there is no indication that the climate was that different from what is seen in the area today. The fluctuating range in climate observed during the last few hundred years in Gujarat could easily incorporate any differences seen in plant occurrence during the Rojdi C occupation.

ROJDI C/D

The final category of recovered botanical remains from Rojdi is from strata representing a mix of both Rojdi C and Early Historical (Rojdi D) material. The last occupation at the site, Rojdi D, occurred many years after the abandonment of the Harappan settlement (Rojdi A, B and C), and consisted mainly of activities on the main mound area of the site. Rojdi D is represented by a series of pits that intrude into portions of the Rojdi C occupation. No material could be identified as purely Rojdi D, since all areas where Rojdi D ceramics were recovered, so were ceramics from other periods of occupation. Therefore, any samples from strata where early historic or historic ceramics were recovered,

regardless as to where in Rojdi the samples came from, were placed into the Rojdi C/D category.

A total of 38 samples, representing 258 liters of floated soil was collected from strata eventually classified as C/D. The majority of the Rojdi C/D botanical remains were from Trench 45K. In all, 2709 seeds were collected, of which 35 percent represented recent contamination. Over half or 1754 seeds were carbonized and from secure archaeological proveniences (tables 32, 33 and 34). Fifty-seven different taxa were identified, including 10 species previously not identified at Rojdi. The cultigens are basically the same species found in the earlier occupation, and they appear in percentages most similar to Rojdi C, except that _Panicum miliare_ and _Vigna_ increase and _Setaria_ decreases in percentage. Since two different occupation phases may have contributed to the material, no further analysis of C/D material will appear at this time. Once the ceramic analysis for Rojdi is completed, many of the carbonized seeds now associated with the Rojdi C/D mixture category may be allotted to either C or D and analyzed accordingly.

Table 32. Distribution of Rojdi C/D samples, soil and seeds.

Trench	Stratum	No. of Samples	Lit. of Soil	No. of Seeds	No. of Taxa	Samples Without Seeds
46K	1-4	5	38	425	28	1
46L	1-3	5	33	173	14	0
45K	1-4	22	140	1881	57	1
Other	1-4	6	47	230	16	2
Total Rojdi C/D		38	258	2709	57	4

Table 33. Material recovered from Rojdi C/D by taxa, with seed counts, percent of Rojdi C/D material, seeds per liter soil (density), percent of samples (ubiquity) and percent carbonized.

Taxa	Number	Percent	Density	Ubiquity	Percent Carbonized
Abelmoschus	4	0.1	0.02	7.8	0
Acacia*	2	0.1	0.01	2.6	100
Boerhavia diffusa	1	0.05	0.01	2.6	0
Borreria	3	0.1	0.01	7.8	100
Carex	9	0.3	0.03	13.1	0
Cheno-Ams	46	1.7	0.18	21.0	50
Chenopodium album	85	3.0	0.33	15.4	100
Chloris	15	0.5	0.06	15.9	0
Convolvulus	1	0.05	0.01	2.6	100
Corchorus	59	2.0	0.23	10.0	22
Cucumis	1	0.05	0.01	2.6	0
Cymbopogon	1	0.05	0.01	2.6	0
Cyperus	2	0.1	0.01	5.2	50
Dactyloctenium	36	1.0	0.14	23.7	40
Digera muricata	16	0.5	0.06	15.9	15
Digitaria	13	0.4	0.05	5.2	0
Eleusine coracana	50	2.0	0.15	13.1	100
Euphorbia granulata	80	3.0	0.34	10.0	5
Euphorbia prostrata	67	2.0	0.27	21.0	5
Euphorbia thymifolia	28	1.0	0.15	5.2	7
Ficus	12	0.4	0.05	7.8	39
Fimbristylis tenera	8	0.3	0.03	7.8	100
Hordeum	3	0.1	0.01	2.6	100
Indigofera	3	0.1	0.01	5.2	10

Table 33. (continued)

Taxa	Number	Percent	Density	Ubiquity	Percent Carbonized
Ipomoea	2	0.1	0.01	2.6	100
Lathyrus	84	3.0	0.33	7.8	100
Linum	2	0.1	0.01	5.2	100
Lotus	7	0.3	0.03	5.2	100
*Medicago**	17	0.6	0.07	13.1	100
Melilotus	11	0.4	0.04	7.8	100
Melochia	1	0.05	0.01	2.6	100
Neptunia	2	0.1	0.01	5.2	100
Panicum miliare	318	12.0	1.23	15.9	100
Panicum sp.	39	1.0	0.15	21.0	95
Paspalum	3	0.1	0.01	2.6	0
Phyllanthus	1	0.05	0.01	2.6	100
Pisum	6	0.2	0.02	5.2	100
Saccharum	12	0.4	0.05	10.0	0
Scirpus	2	0.1	0.01	5.2	100
Setaria tomentosa	15	0.5	0.05	21.0	100
Setaria glauca	30	1.0	0.11	10.0	70
Setaria italica	108	4.0	0.51	26.3	70
Setaria sp.	4	0.1	0.01	2.6	75
Solanum	13	0.4	0.05	15.4	40
Sorghum	89	3.0	0.34	13.1	100
Tragus	11	0.4	0.04	13.1	0
Trianthema decandra	614	23.0	2.21	44.7	30
Trianthema trequetra	22	8.0	0.15	18.4	30
Trianthema portulacastrum	1	0.05	0.05	2.6	0
Verbascum	5	0.2	0.02	5.2	0
Vicia	1	0.05	0.01	2.6	100
Vigna radiatus	4	0.1	0.02	5.2	100
Vigna sp.	21	0.8	0.08	2.8	100
*Vigna angularis**	17	0.6	0.06	5.2	100
*Vigna unguiculata**	9	0.3	0.03	7.8	100
Zizyphus	2	0.1	0.01	5.2	100
Unidentifiable	688	25.0	2.67	44.7	70
TOTAL/AVG	2709	100.0	10.5	-	65

* not found in earlier levels of Rojdi.

Table 34. Types of Rojdi C/D samples.

Sample Provenience	No. of Samples	No. of Seeds	Liters of Soil	Samples with no Seeds
pits	20	1401	171	0
trash	2	36	18	0
general fill	6	382	31	4
soil column	6	460	24	0
surface/ stratum 1	3	429	13	0
pot associated	1	1	0.5	0
TOTAL	38	2709	258	4

Rojdi Plant-Use : The Common Elements

A general subsistence pattern appears at Rojdi throughout all phases of occupation. Although we presently lack proportions and numbers of the faunal remains at the site, the animal portion of the subsistence does suggest that this was a site where animal husbandry and hunting were going on, and where cattle, and some sheep and goats were actually being raised. Similarly, there is a general plant-based subsistence system occurring, one which was based on a single group of recurring taxa that make up the bulk of the archaeobotanical record in all phases of occupation.

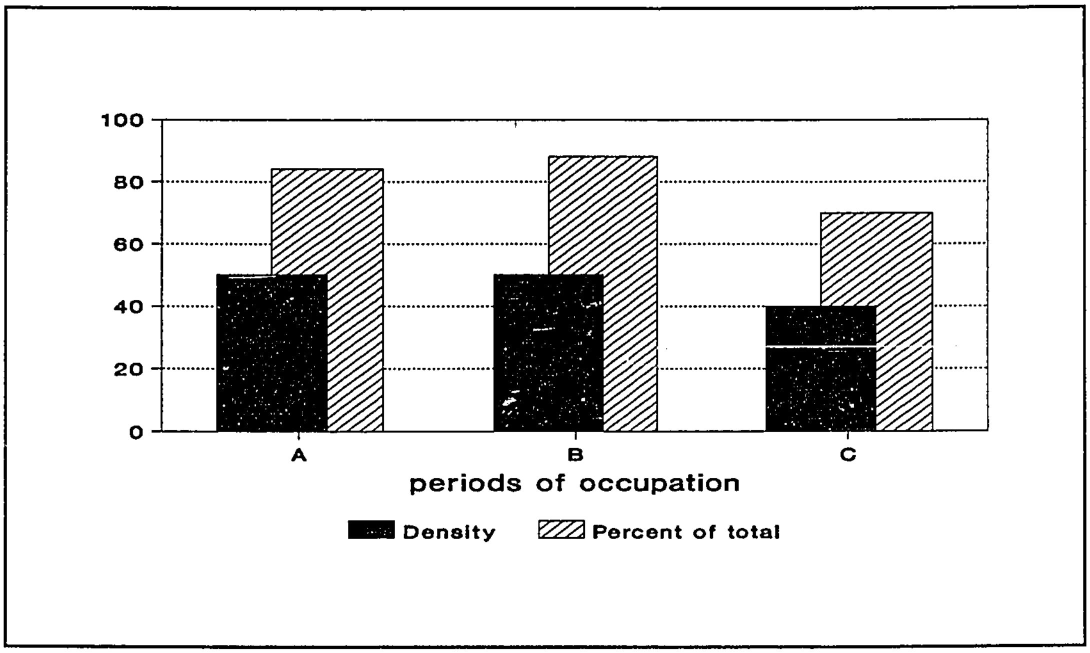
Thirteen plant taxa, or plant categories (*Chenopodium album*, *Dactyloctenium aegyptium*, *Digera muricata*, *Eleusine coracana*, *Euphorbia* sp., *Ficus* sp., *Indigofera* sp., *Melilotus*

sp., Panicum miliare, Panicum sp., Setaria sp., Trianthema sp.), were observed in all periods of Rojdi occupation (A, B, C and C/D). Carbonized remains of these plants from secure proveniences account for over 70 percent of the recovered archaeobotanical material from Rojdi A, B and C (figure 26 and table 35). Not only do they represent a high percentage of Rojdi plant remains, but at least one of these 13 taxa are represented in nearly every sample from the site. Further, they add up to an average density of greater than 19 seeds per 10 liters of soil.

Table 35. Comparisons of percentage (P), ubiquity (U) and density (D) of archaeobotanical material only found in Rojdi A, B and C.

TAXA	A			B			C		
	P	U	D	P	U	D	P	U	D
Cheno-Ams	0.2	4	0.01	0.1	3	0.005	0.3	3	0.01
Chenopodium album	3.4	17	0.21	57.0	32	2.8	3.0	8	0.06
Dactyloctenium aegyptium	0.4	7	0.03	0.3	6	0.01	1.0	6	0.03
Digera	0.2	1	0.01	0.1	3	0.005	3.0	11	0.07
Eleusine	62.0	31	3.86	5.0	58	0.29	3.0	10	0.09
Euphorbia	0.4	5	0.02	0.1	3	0.005	1.0	5	0.03
Ficus	0.6	5	0.03	0.3	6	0.01	0.5	1	0.02
Indigofera	0.4	5	0.02	0.3	6	0.01	0.6	3	0.02
Melilotus	0.2	3	0.01	0.2	3	0.01	0.5	1	0.02
Panicum	0.8	7	0.05	1.0	9	0.06	3.0	19	0.08
P. miliare	12.0	32	0.77	21.0	57	1.02	3.0	11	0.07
Setaria	1.6	18	0.09	1.0	25	0.06	33.0	56	1.00
Trianthema	1.2	18	0.08	2.0	22	0.09	18.0	28	0.50
Total/avg.	83.4	-	5.16	88.4	-	4.33	70	-	1.96

Figure 26. The common plant-based subsistence at Rojdi, comprising 13 recurring taxa.

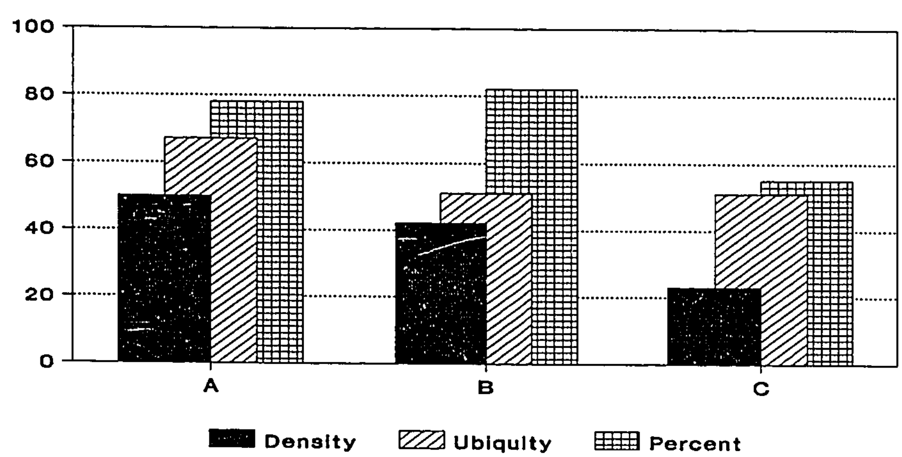


At a finer level of analysis, four common food plant taxa (<u>Eleusine coracana</u>, <u>Panicum miliare</u>, <u>Setaria sp</u>., and <u>Chenopodium album</u>) emerge from this list of 13 and account for a significant portion of the archaeobotanical material from each occupation. Not only are these four taxa represented in high percentages, densities and ubiquities (figure 27) in Rojdi A, B and C, but as a group of food plants they permit some generalizations to be made regarding the status of human-plant interrelationships occurring at Rojdi.

When cultivated, none of these four taxa need intensive human involvement. While irrigation, manuring and weeding may enhance the yield, they are not necessary for a reasonable harvest. Further, the methods of planting, harvesting, winnowing and processing into a consumable food involve similar procedures. Contemporary activities involving these plants observed in regions of South Asia may suggest the nature of some of these procedures. These taxa are generally grown as a mixed crop in turned soil. After maturing, the dried stalks are often (though not always), cut close to the ground and dried prior to threshing. The separation of the dried ears is accomplished through either beating with sticks or trampling by bullocks. The remains are then winnowed, cleaned and subsequently, depending on need, ground into flour and baked into breads, or boiled into puddings, porridge or gruel.

Three of these four recurring taxa can also be classified as millets, for example, E. coracana or finger millet, P. miliare or little millet, and Setaria italica or Italian millet. A physical feature all three of this millets share, but is not part of the common definition of a millet, (for this definition, refer to the preceding chapter) is that they all have small seeds, whose compacted heads contain many seeds. The smallness of the seeds means they dry out more rapidly and easily, and the large numbers of seeds per head means that larger numbers of seeds could be collected more

Figure 27. Density, ubiquity and percent of four main recurring taxa (C. album, E. coracana, Setaria and P. miliare) probably used for food in Rojdi A, B and C.



rapidly. Whether these are characteristics that the Rojdi occupants were concerned with can never be known, but the fact that the fourth member of this group of common food plants, C. album, shares these same characteristics with the millets, suggests that they may have been.

If we graph out the occurrence of the three millets, (less the weed seeds), for each period of occupation and look at the percent of material they represent, the different percentages of millets between occupation periods exceeds 50 percentage points (figure 28). If, however, we add in C. album, the difference between phases decreases to less than 10 percentage points. If we do the same procedure for plant

ubiquity, a similar pattern appears, albeit less dramatic, with a difference of nearly 20 points between phases among the millets alone, becoming less than 10 when C. album is added in (figure 29). It may be worth pursuing the idea that, for the Rojdi inhabitants, C. album was associated with the millets in a way that is obscured by our use of contemporary, scholarly plant categories.

In all likelihood, the three millets E. coracana, S. italica, and P. miliare were being cultivated at Rojdi, and since they share certain characteristics regarding cultivation practices, a general picture can be developed on such a basis regarding agricultural subsistence at Rojdi (table 36). These three species are well suited for a variety of soils and for hot, dry conditions. They are all considered drought resistant, needing an annual rainfall of between 30 and 70 cm. Although they may need little water to grow, and can produce some seeds in years of minimal rainfall, their growing season is associated with the summer monsoon weather system. Too much water may be harmful, and waterlogged soils cause many more problems than the lack of water. Once planted, they take between two and four months to mature and provide nutritional seeds and fodder. Once again it is interesting to note that cultivated C. album fits most of these criteria, with the exception of cropping season. C. album is generally found growing in the spring time in South Asia.

Figure 28. Differences in percentage between Rojdi A, B and C millets and millets with the addition of <u>C. album</u>.

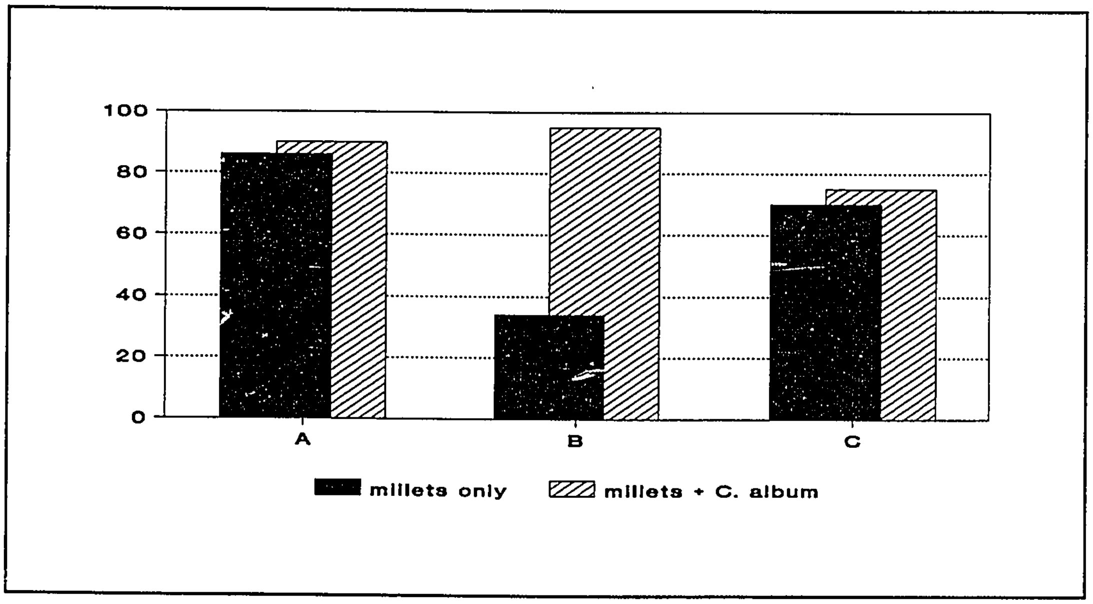


Figure 29. Differences in ubiquity between Rojdi A, B and C millets and millets with the addition of <u>C. album</u>.

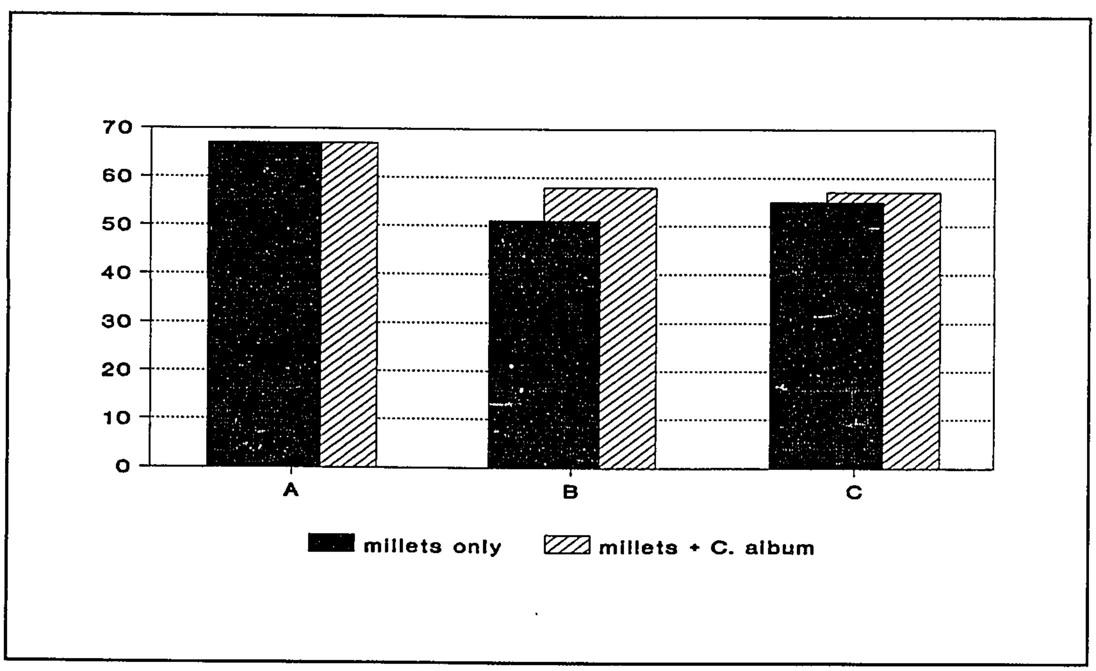


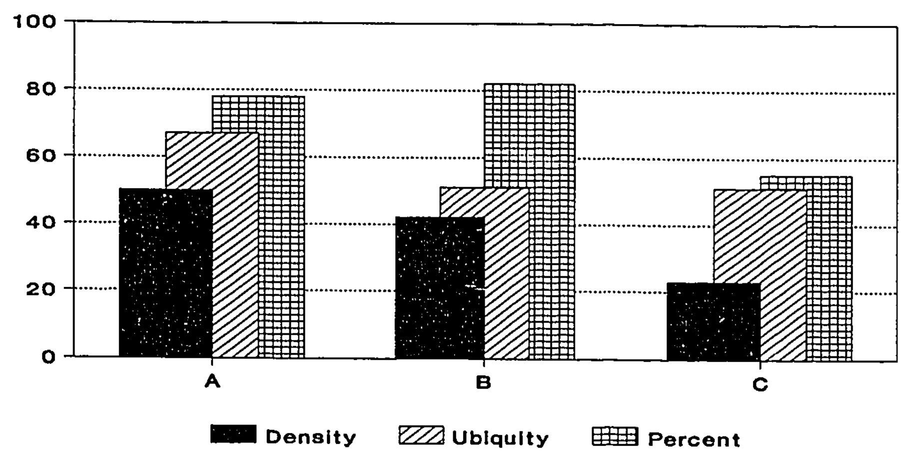
Table 36. Common characteristics regarding the cultivation of millets.

CHARACTERISTICS	AVERAGE
Annual Rainfall	30-70cm
Soil Type	Wide Range
Cropping Season	Summer
Time to Mature	2 to 4 Months
Management	Little Needed
Nutritional Seed Value	Good
Fodder Value	Good
Cultivation Method	Dry Framing
Drought Resistant	Very

Cultivation seems to have been important at every phase of occupation. If the number of seeds representing species which were probably being cultivated at Rojdi are added together for each period of occupation, nearly 80 percent of archaeologically deposited seeds represent cultivated plants (figure 30). Not only is there little change in this percentage from one occupation to another, but it suggests a relatively high dependence on cultivated plants or species which were intensively managed. This high percentage is corroborated by the calculations for density and ubiquity.

In summary, Rojdi in general is best viewed as a food producing settlement occupied throughout the year, where cultivation and various pastoral activities were being

Figure 30. Cultivation at Rojdi based on estimates of likely food plants for each occupation.



performed locally and were supplemented by plant gathering and hunting. The bulk of cultivation centered on plants producing small seeds from compacted heads and a summer monsoon based weather system, although plants representing other season were recovered. From the time Rojdi was settled to the time it was abandoned, cultivation and the use of domesticates was going on. Finally, the plants being exploited never needed intensive human involvement and were all hardy, drought-resistant species, implying a climate and

habitat not that different from what is found in the region around Rojdi today.

Rojdi Plant-Use : The Differing Elements

While certain plant and animal species are common throughout all phases of Rojdi, the subsistence system is not without variation and change. Although no faunal data is presently available for the description of variation and change, the plant usage patterns display significant change during the multi-phase occupation. This change is less a shift to new species than to altered dependence on existing ones. While the number of species being exploited does increase, the majority of the recovered remains from each occupation period are the same, reoccurring species.

In an effort to compare Rojdi A, B and C plant remains to show above average occurrence of any given species, a method was devised which would incorporate all three quantitative methods of analysis (percentage or proportion, density, and ubiquity). Cut-off points were calculated for each of these quantitative methods, above which only the above-average plant occurrences would register. For percentage, this would mean that a plant species would have to account for above four percent of the recovered material deposited during a given occupation in order to register. For density, all species which had an average rate of one seed

per three liters of soil from a given occupation would register. And finally, a ubiquity rate of greater than from 18 percent of the samples from a given occupation at Rojdi would also register. Based on these criteria, six taxa registered above average in at least one category during either Rojdi A, B, or C (table 37). Four of these taxa (C. album, E. coracana, P. miliare and Setaria) are the same re-occurring food plants found throughout Rojdi, one is a common weed (Trianthema sp.) and the final taxon represents a probable food plant (Zizyphus sp.), but which registered in only one category (percentage) and in only one occupation (Rojdi A).

Table 37. Rojdi archaeobotanical remains with above average occurrence.

TAXA	A	B	C
Chenopodium	2,3	1,2,3	0
Eleusene	1,2,3	1,3	0
Panicum	1,2,3	1,2,3	0
Setaria	0	3	1,2,3
Trianthema	0	3	1.2,3
Zizyphus	1	0	0

1- Greater than 4 percent of material from occupation.
2- Greater than 1 seed per 3 liters of soil.
3- Recovered in more than 20 percent of the samples from an occupation.

These six taxa account for more than 60 percent of the identifiable, carbonized material from secure proveniences, and suggest a certain amount of homogeneity in the Rojdi

plant record. Yet, further examination does show variation in their distribution and quantities throughout the occupation of the site. What first becomes apparent is that Rojdi A and B have more in common with each other than either has with Rojdi C. C. album, E. coracana and P. miliare register above average in at least two of the three quantitive categories during occupation A and B, and fail to register at all in Rojdi C. In contrast, Setaria sp. and Trianthema sp. fail to register at all in Rojdi A, only register in the ubiquity category in B, yet are above average in all categories in Rojdi C. Therefore, based on the plant record alone, Rojdi A and B should be regarded as subphases of one occupation phase, and Rojdi C a different occupation phase altogether. Furthermore, not only does the archaeobotanical material in Rojdi B appear as a subphase of Rojdi A, but it may contain the first indication of efforts at attempting to adapt to a form of stress, specifically in the heightened occurrence of C. album. Perhaps this adaptation was in part responsible for initiating changes that mark off Rojdi C so clearly from A and B.

By focusing on five of the recurring and prominent plant taxa (excluding Zizyphus sp.), and by charting the occurrence of each species separately throughout the occupation of the site, a changing strategy regarding the usage of these taxa emerges (figures 31, 32 and 33).

Figure 31. Based on ubiquity, the distribution by occupation of the 5 most common Rojdi taxa.

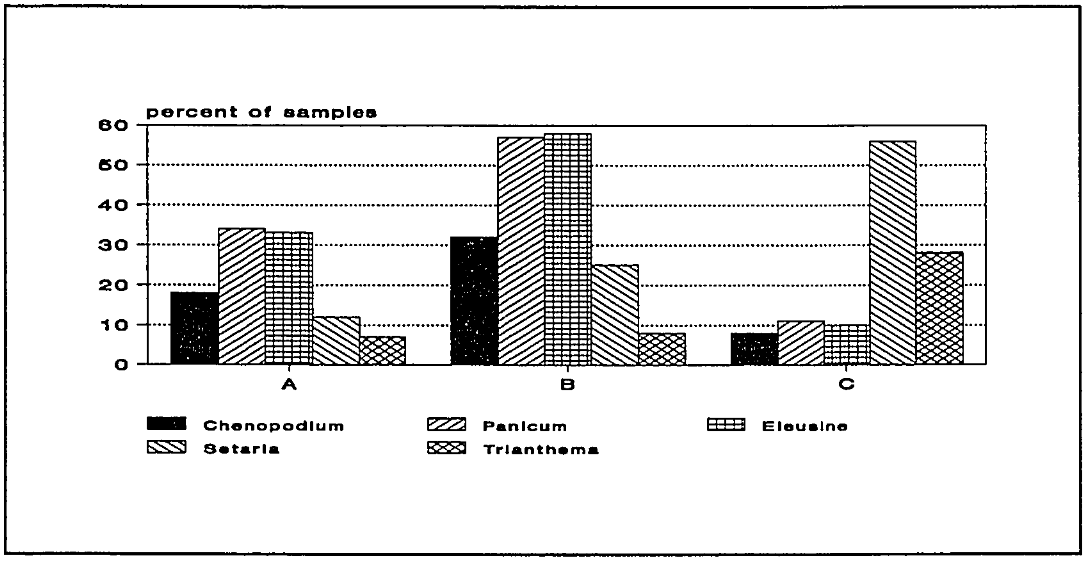


Figure 32. Based on percent, the distribution by occupation of the 5 most common Rojdi taxa.

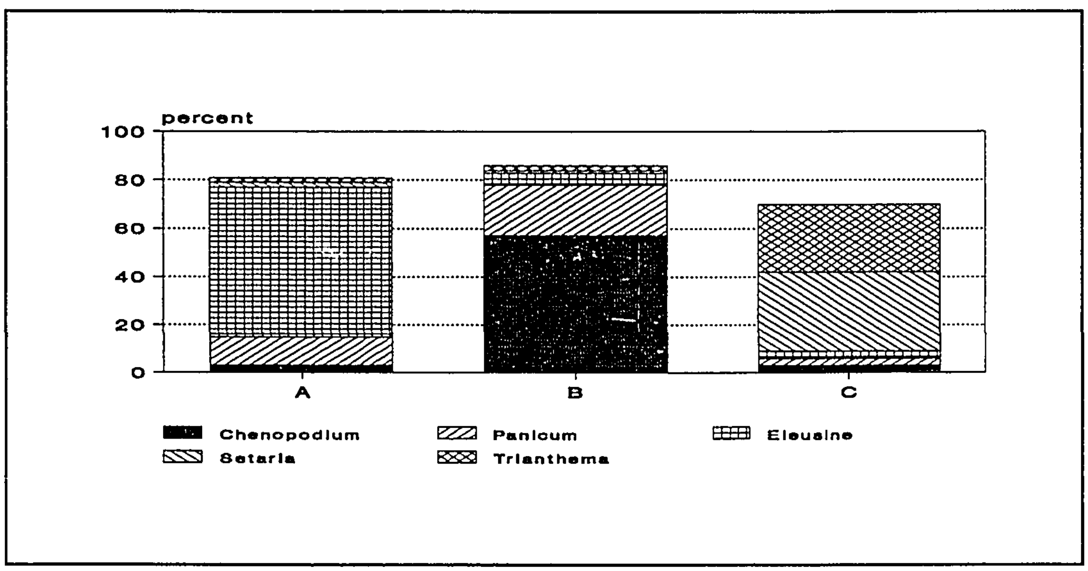
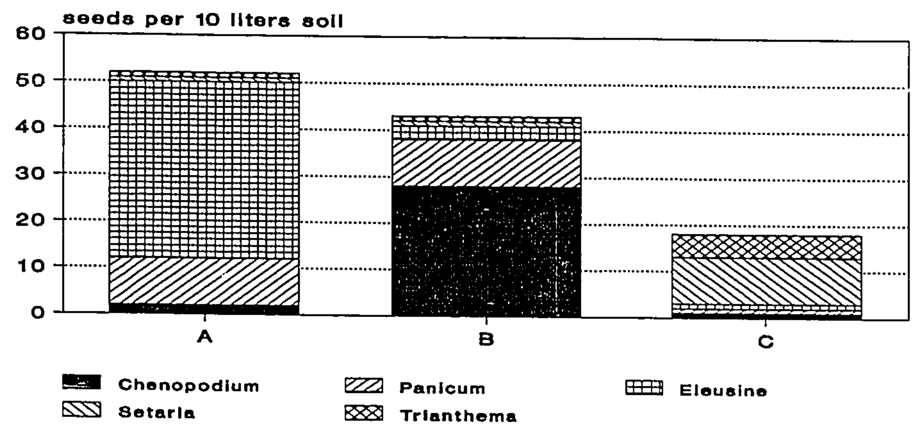


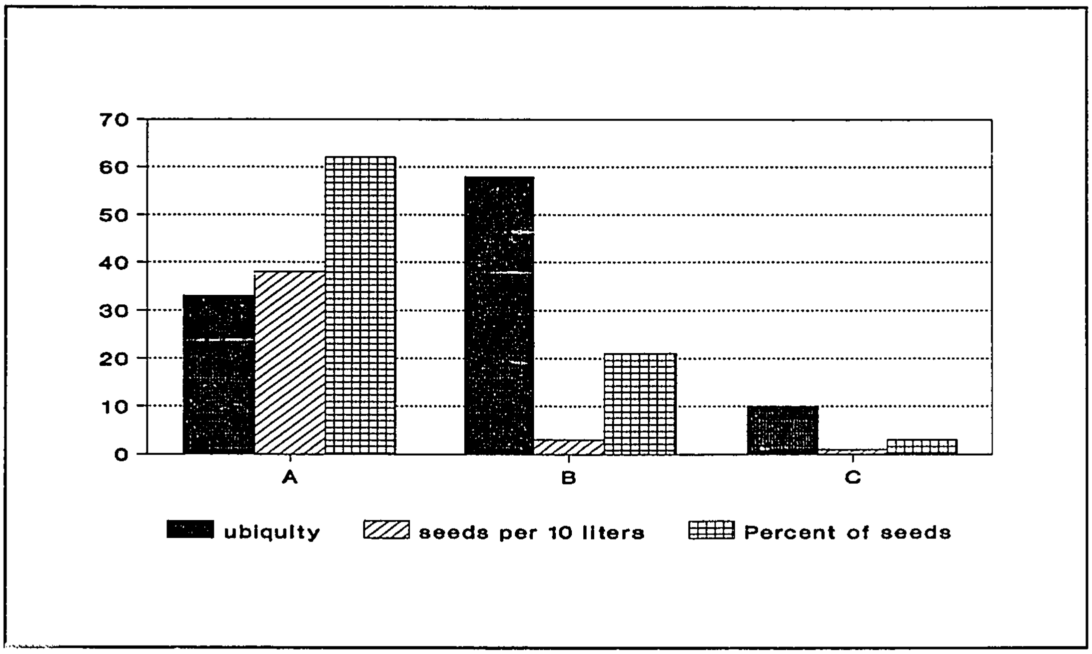
Figure 33. Based on density (seeds per 10 liters soil), the distribution by occupation of the 5 most common Rojdi taxa.



First, E. coracana, which shows a significant drop in percentage, ubiquity and density from Rojdi A to C (figure 34). During Rojdi B, E. coracana drops in percentage and density, though not to the levels found in Rojdi C, while the ubiquity actually goes up to a level approaching 60 percent. This pattern implies that while the overall trend is for a decreasing usage of E. coracana during Rojdi B, more accidents, (causes of preservation involving accidental carbonization), involving fewer numbers of grains occurred. On the other hand, Rojdi C does show few accidents involving

few seeds (low density, percentage and ubiquity), suggesting a much lower usage than occurred earlier at Rojdi.

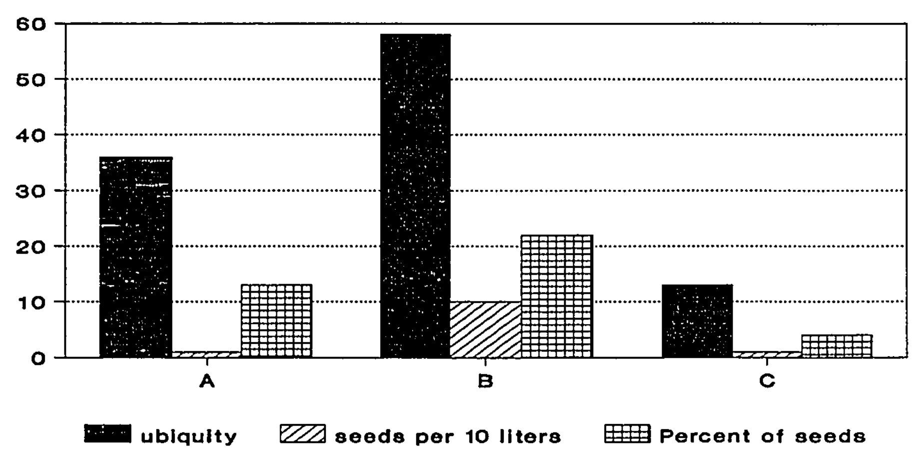
Figure 34. Temporal distribution within Rojdi of Eleusine coracana.



Panicum miliare shows a similar pattern to E. coracana, but to a lesser degree (figure 35). In both Rojdi A and B, the percentage of grains and the number of samples with this species were significantly higher than Rojdi C. In contrast to E. coracana, P. miliare shows increases in ubiquity, density and percentage in Rojdi B over A. Rojdi C displays a decrease in P. miliare according to all methods of

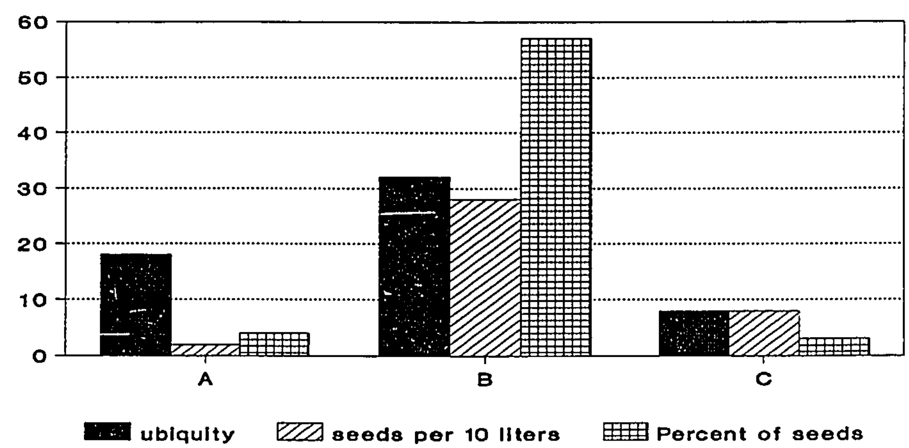
computation compared to B. By Rojdi C, P. miliare is occurring at a rate roughly comparable to E. coracana.

Figure 35. Temporal distribution within Rojdi of Panicum miliare.



The pattern for C. album is more like P. miliare than any other food plant, in that it occurs most frequently in Rojdi B (figure 36). But like both P. miliare and E. coracana, it occurs at the same low density, ubiquity and percentage in Rojdi C. Interestingly, the numbers for all three species are nearly identical in Rojdi C -- 3 percent of the total, less than 1 seed per liter soil and a ubiquity rate of nearly 10 percent.

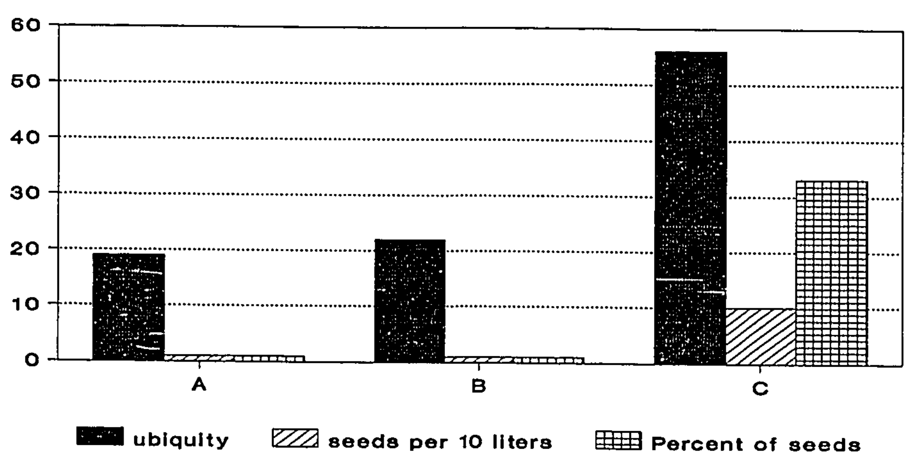
Figure 36. Temporal distribution within Rojdi of Chenopodium album.



In contrast to these four species, the pattern of Setaria usage at Rojdi is the simplest to follow. In Rojdi A and B the occurrence of Setaria is nearly the same, at a very low density percentage and ubiquity (figure 37). In Rojdi C, Setaria sp. increases according to all three methods of calculation to over three times the levels seen in A or B. While Setaria sp. is referred to here as a single category, in reality three independent species have been identified, at least tentatively. While the most prominent is S. italica all three Setaria species show the same pattern independently as presented here for Setaria sp. as a group. By the Rojdi C occupation, Setaria sp. becomes the most

commonly recovered food plant, occurring at over 10 times the rate observed for E. coracana, P. miliare, or C. album. There is no doubt that not only has Setaria sp. increased in occurrence, but this increase is at the expense of the food plants which previously were most common.

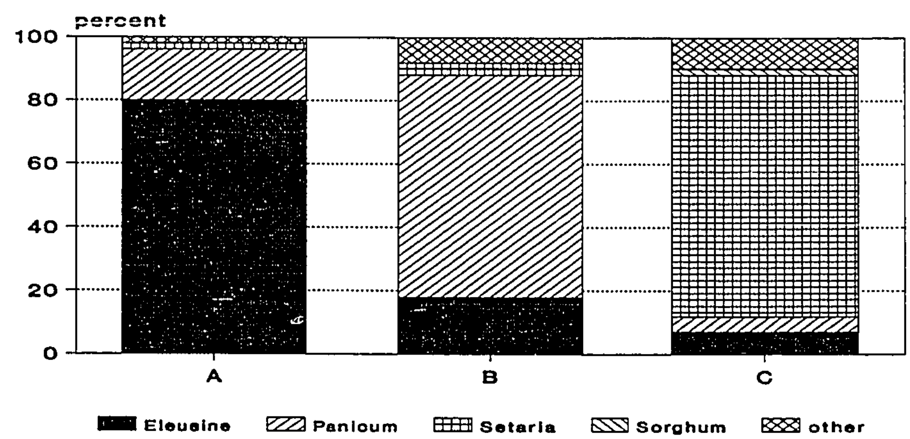
Figure 37. Temporal distribution within Rojdi of Setaria.



The inclusion of other, less common millets from the Rojdi occupation (e.g. sawa millet (E. colonum) and kodo millet (P. scrobiculatum) does not controvert the general picture that has been sketched (figure 38). Once again, the plasticity of these species with regard to environment and weather conditions within a certain range, implies that while climatic fluctuation may have been a problem for the Rojdi

inhabitants, a change in the proportions of millet crops may have been more the result of culturally-based decisions than of lasting, dramatic environmental change.

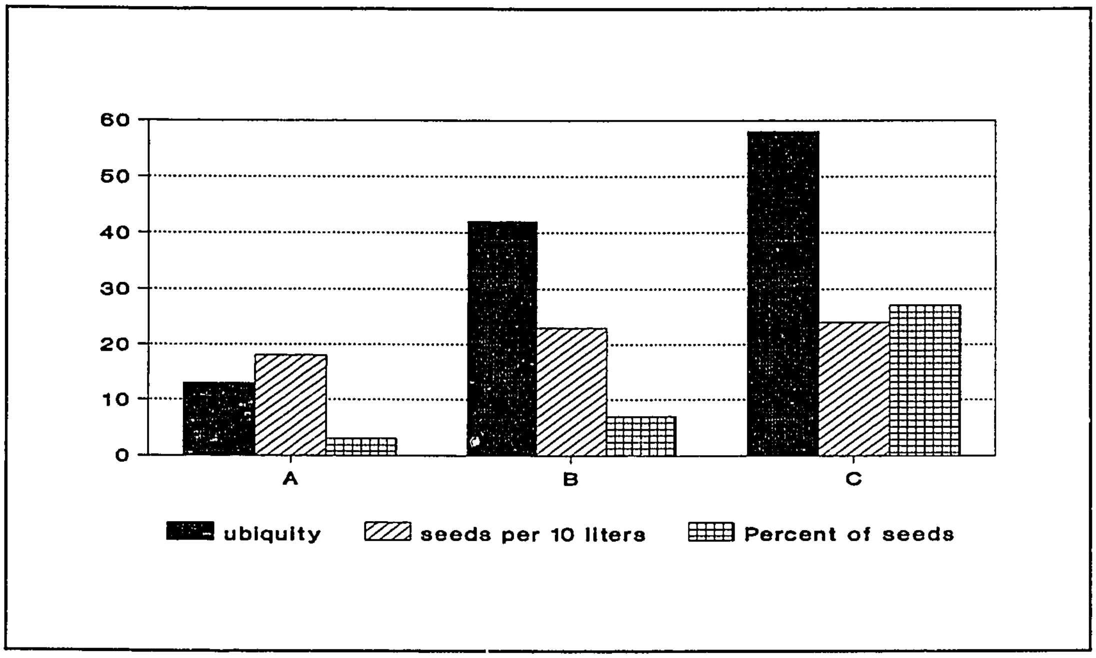
Figure 38. Millet percentages for Rojdi A, B and C.



One of the recurring taxa which also registered as one of the above average occurring taxa (table 36) is Trianthema, a common weed. Increased occurrence in successive levels of Trianthema is shared by other weed species, so that by Rojdi C they represent nearing 30 percent of recovered carbonized remains. The taxa in this category include Cheno-Ams, T.

<u>decendra</u>, <u>T. portulacastrum</u>, <u>T. triquetra</u>, <u>E. granulata</u>, <u>E. prostrata</u>, and <u>E. thymifolia</u>, as well as many of the common weedy grasses. While the ubiquity and percentage of weed seeds steadily increase in successive levels, the density of weed seeds remains much the same, with only a very slight increase over the occupation of the site (figure 39).

Figure 39. Temporal distribution of weed plants for Rojdi.

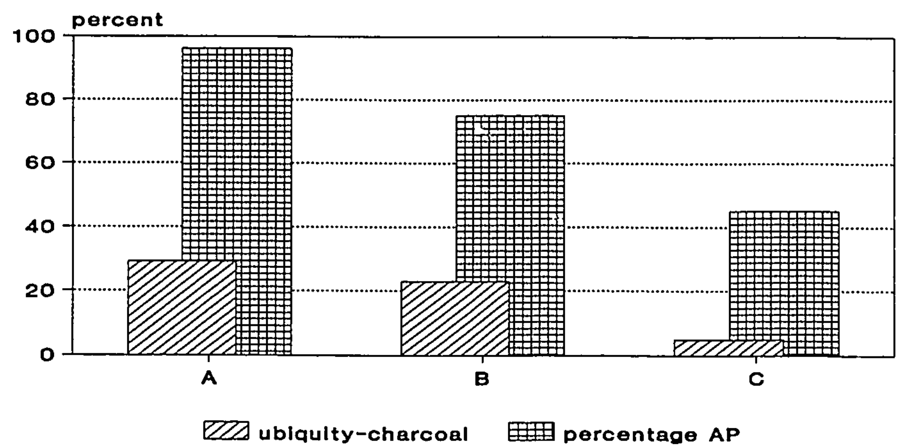


The plants in this category are mostly shrubs and herbaceous species and grow well in disturbed areas. Any soil which has been altered by means of occupation, building, cultivation practices, or any erosional cycles is classified as disturbed. In general, the level of disturbance plants

is related to the degree of disturbance (Halbirt 1978; Minnis 1978). Therefore, if the level of disturbance is reflected by the land area assumed by these plants, might there be a corresponding relationship in the archaeological record, so that an increase in the occurrence of plants associated with disturbance implies an increase in actual disturbance? Further, is an increase in percentage, density and ubiquity of disturbance plants an indication of local habitat manipulation? While an increased population, intensification of cultivation practices, and a change in herding practices could all be used to explain this trend toward increasing levels of disturbance species, natural factors like flooding or erosion could also explain this pattern. When other methods for determining the effect of human population on the local habitat are included in the Rojdi interpretation, such as pollen and charcoal analysis, a clearer picture begins to take shape.

While to date only preliminary pollen analysis has been completed, it presently shows an increase in non-arboreal pollen (NAP) over counts of arboreal pollen (AP). Further, counts of pollen grains representing disturbance species also show an an increase (figure 40). While this pollen is collected from cultural, not natural contexts, and thus may be biased, it none the less supports the perception of change occurring in the local habitat as a result of human interference.

Figure 40. Indications for habitat change around Rojdi.

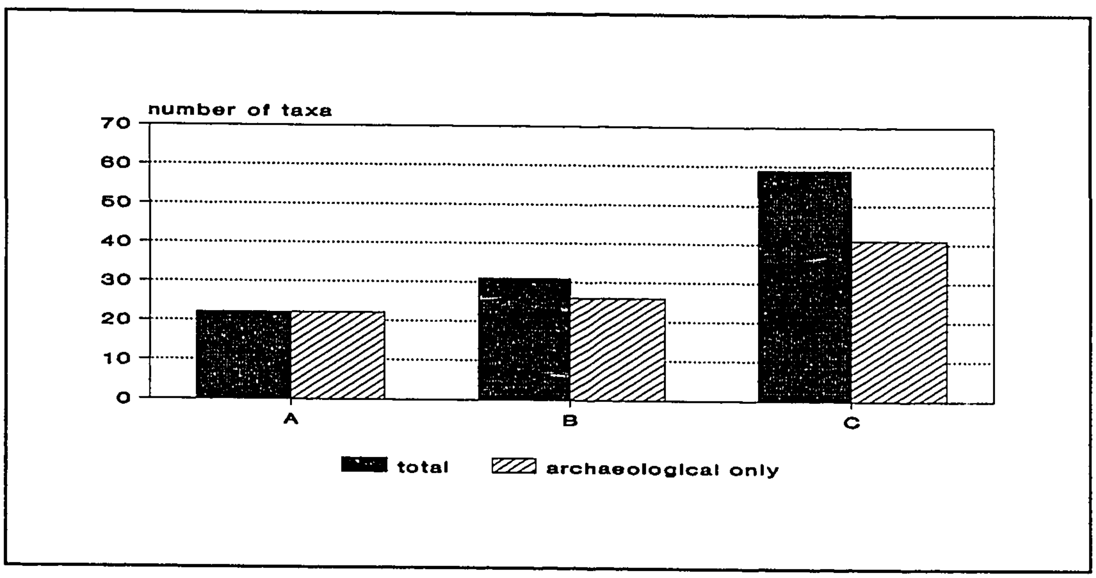


While the amount of charcoal represented in Rojdi remains at a low level throughout the occupation, its density, weight and ubiquity rates continue to drop in successive levels of the site. If charcoal is related to the burning of wood, and thus to the availability of trees of shrubs, any decrease in its occurrence may be due to a decrease in wood as a source of fuel. In order to compensate, there should be an increase in the use of other sources like dung, the most common source of fuel in the region today. Since the archaeobotanical record shows a shift to <u>Setaria</u>, which is a poor cattle fodder, increased dung use should be matched in the faunal record by a shift

away from cattle and towards sheep and goat. Decreases in charcoal and in the density of carbonized seeds, accompanied by an increase in arboreal pollen and disturbance plants, consolidates our argument for a change in the local habitat as a result of human activity.

While each occupation phase contains taxa unique to that phase, the largest number of new species occur in Rojdi C, new species that are, moreover, mostly food plants (figure 41). Of the 29 taxa observed only in Rojdi C, more than half were carbonized and deposited during this occupation. Though their usage is low based on their actual numbers (density, percent and ubiquity), their appearance alone is significant.

Figure 41. Number of different taxa identified for Rojdi A, B and C.

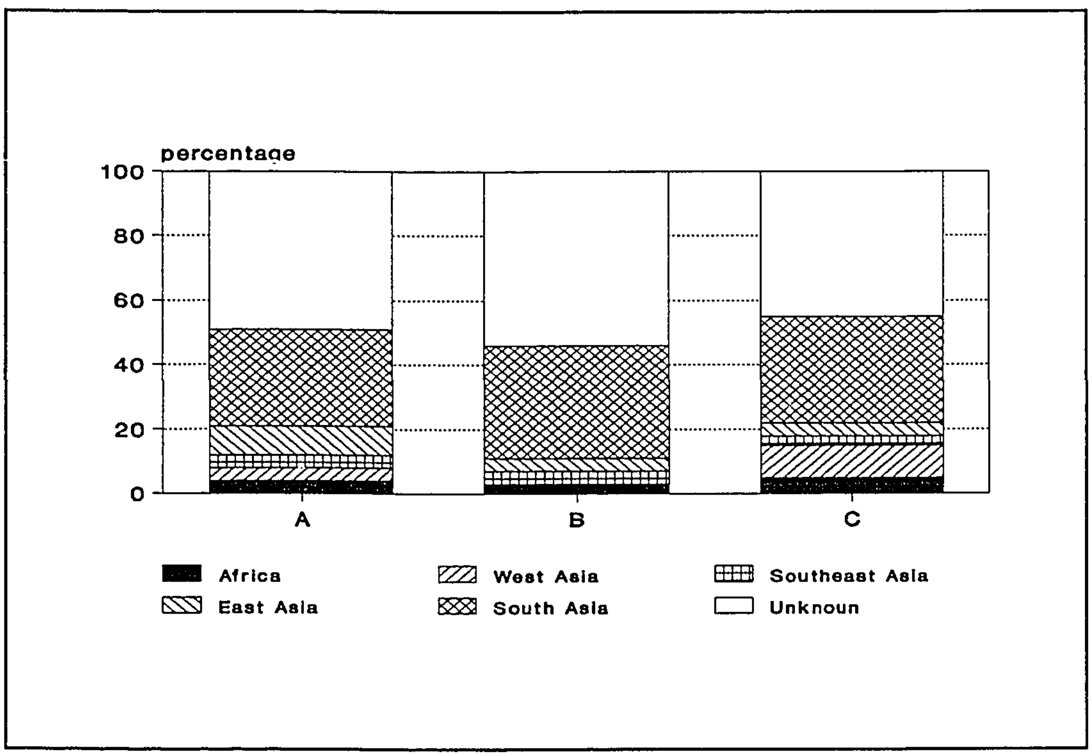


The most interesting of these new taxa are jowar, sawa millet, grass pea, linseed, and green gram. What makes these species interesting is either their origin or probable season of cultivation.

The addition of new species to the Rojdi record which were not indigenous to South Asia suggests continued or periodic direct interaction with people outside South Asian, or with intermediaries who had contact with non-South Asia populations. A good example is provided by two plant species (_E. coracana_ and _Sorghum bicolor_) both believed to be of African origin based on archaeological, linguistic, morphological and genetic studies (Weber 1988). _E. coracana_ is found in the earliest levels of Rojdi implying its use as early as 2600 B.C. in Gujarat. _Sorghum_ appears much later in Rojdi C. Presumably, these plants entered Gujarat at different times, supporting the argument of either continuous or multiple periods of interaction with people in Africa, or with people who had contact with African populations. Rojdi also shows a general pattern of increasing outside influence based on the heightening incidence of non-indigenous plant species through the occupation (figure 42). Many of these new taxa found in Rojdi C are considered winter crops. Though small in number, the presence of linseed, grass pea and other pulses imply an increasing focus on winter cultivation. If this occurred as it does today around Rojdi, the low river water would have been diverted to shallow

irrigation ditches in the dry portion of the river bottom. Smaller percentages among the taxa solely suited to summer cultivation seems to corroborate the view of an increasing tendency toward non-summer cultivation. However, while winter cultivation probably occurred and increased in importance during the Rojdi C occupation, summer cultivation was still the primary focus, with wild plant collecting remaining a supplementary activity.

Figure 42. Most likely place of origin for Rojdi material.



The lack of certain plants in any given occupation at Rojdi is as intriguing as the presence of species already noted. The lack of pearl millet (Pennisetum typhoideum) and rice (Oryza) in Rojdi A, B or C is worth noting, since both are commonly grown in the region today, are found in archaeological sites contemporary with Rojdi, some of which are quite close to Rojdi (e.g. Gujarat). Finds of pearl millet at Hallur, Rangpur and Ahar, and rice at Lothal, lead us to question why neither species shows up at Rojdi.

Based on the common elements of the plant use strategy found at Rojdi, and on various aspects of its evolution over the entire occupation, a Rojdi subsistence model will be constructed. This model will attempt to explain the seed variability occurring at Rojdi in terms of the plant portion of its subsistence base.

CHAPTER IX. THE ROJDI PLANT USE/SUBSISTENCE MODEL

Rojdi subsistence formed a major interface between the site's inhabitants and their environment. Since this interface was an organized system whereby humans extracted and exploited the necessary resources (plants and animals) for survival, it left remains in the archaeological record that permit the analysis and tentative reconstruction of the subsistence system. The plant contribution to the Rojdi subsistence economy includes a variety of plants serving different roles and assuming a place in different types of activities, procedures, technologies and organization.

Plant Use Strategy

The Rojdi inhabitants' plant-usage strategy was derived from an evaluation of available resources, itself based on a well-developed knowledge about resources which existed prior to the settlement of the site. At the time Rojdi was settled, the inhabitants not only were aware of which species to exploit, but had previously developed a plant-usage strategy which was implemented at the earliest levels of the occupation. The existence of such a plant-usage strategy is

confirmed by the appearance of cultigens in the earliest levels of the site.

The archaeobotanical record at Rojdi suggests that there were a variety of plants present and that deliberate manipulation of particular species, which make up the majority of the Rojdi plant complex, was occurring for human use and consumption (figure 43). While it is not always possible to distinguish archaeologically between species being tolerated, collected, encouraged or tended, they are generally distinguishable from the species that were cultivated and domesticated. Yet, if the tasks that comprise the manipulation of these species are examined according to these distinct forms of human involvement, it becomes apparent that once food plants enter into the sphere of human activity, the limited and repetitive actions to which they are subjected are very similar. The chief differences lie in the means by which different species are continually introduced into the system itself.

Initiation and maintenance of a viable plant procurement system include processes of planting, managing, selecting and harvesting of usable taxa. Different sets of decision-making processes and technologies are put to work, depending on the kinds of plants involved. Three plant procurement strategies can be devised for Rojdi which account for the plant complex at this site.

Figure 43. The types of human involvement associated with the 13 taxa included in Rojdi plant complex.

1. Unwanted or accidentally included in the archaeological record -- this category includes those species that were neither collected, tolerated nor intentionally grown, yet none the less appear in the archaeobotanical record at Rojdi. Most of the species in the category are the unusable weeds found growing around the site.

2. Tolerated or collected in the wild -- this category involved those species that are found growing and are either collected for use or left alone for in place for some reason but are not weeded out. This may include species used for bordering fields (ie. Euphorbia), medicinal purposes, or as an occasional food.

3. Encouraged or tended -- these are plants which are encouraged to grow means of weeding. They are species cared for in some limited way usually by removing unwanted species or some form of pruning.

4. Cultivated or simple sowing -- this category involves one of the simplest forms of plant husbandry, that involving the intentional dispersal of seeds. Through such techniques as broadcast sowing seeds are deliberately scattered for future harvesting.

5. Domestication/agriculture -- by differing domestication as the "cultured selection for useful phenotypic characters resulting in new plants dependent upon humans for their existence," (Ford 1985:3), this category would include those species which not only are being cultivated but have become a "cultural artifact."

Taxa included in the Rojdi Complex	Levels of human involvement
Cheno-Ams	1, 2
Chenopodium album	2, 3, 4
Dactyloctenium aegyptium	2, 3
Digera muricata	1, 2
Eleusine coracana	4, 5
Euphorbia	1, 2
Ficus	2, 3
Indigofera	2, 3
Melilotus	2, 3
Panicum miliare	3, 4
Panicum sp.	3, 4
Setaria	3, 4, 5
Trianthema	1, 2

The first strategy involves the gathering of wild seeds. Areas around the site, near to, or inside cultivated and fallow fields were probably being exploited for this purpose. While some of the wild species may have been actually encouraged to grow, as a whole these plants were simply tolerated and used as a supplement to other portions of their diet. Once harvested they were processed in ways similar to the cultivated species. In times of increased food stress, whether this was induced by natural or cultural causes, there was probably an increased dependence on this category of plants. The archaeological evidence at Rojdi implies existence of this strategy but suggests that it never became more than a minor focus for the site's inhabitants.

The second strategy involved irrigation agriculture. While it is not possible to positively document its existence at Rojdi, since no direct evidence was found in the form of dams, canals, and so forth, there is indirect evidence in the form of certain plants which are better suited to irrigation agriculture than any other form of farming. Though it probably never accounted for more than a small portion of the plant procurement system at Rojdi, the use of irrigation broadened the inhabitants' plant dependence by increasing the number of species which could be exploited. It also enabled the occupants at Rojdi to better distribute their plant procurement efforts throughout the year by allowing non-monsoon season cultivation to take place. Irrigation

probably took place in the river basin during the winter, much as it is done today in this region of Gujarat. Irrigation agriculture generally requires an increased labor expenditure than other types of cultivation (Boserup 1965), but also may produce a greater yield per unit of area.

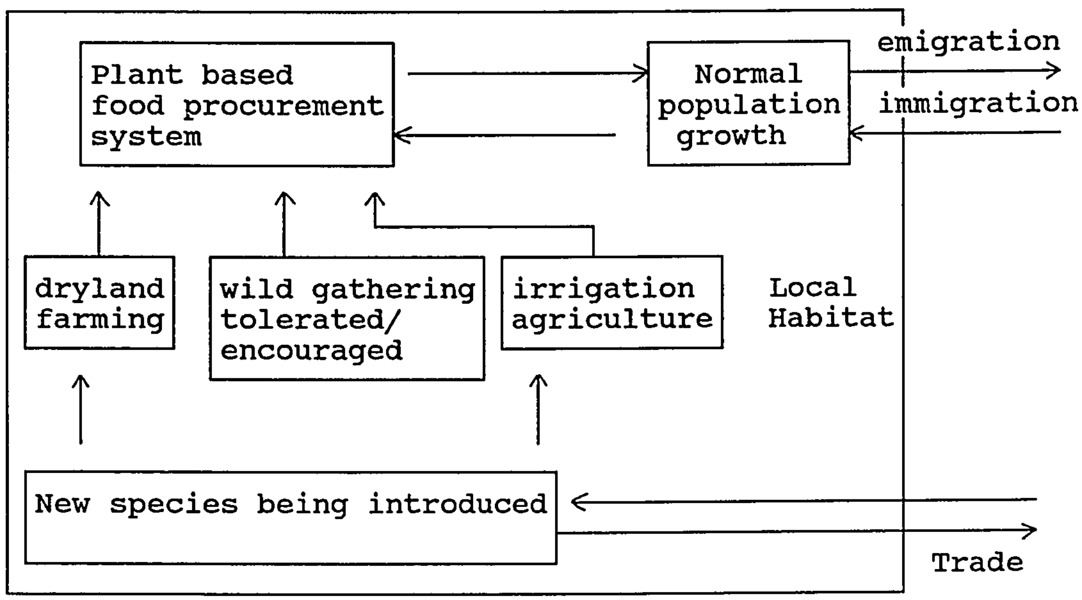
The third and most important strategy at Rojdi was dry farming. With a regional moisture system that was centered on the summer, with little or no rainfall during other times of the year, a focus on dry farming would seem to have been a reasonable option. The Rojdi inhabitants appear to have focused on plants that produce maximum quantities of dry matter, using a minimum quantity of water, and with the shortest possible period of growth. The result was a major dependence on small-seeded grasses with compacted heads suitable for dryland farming. For Rojdi, this appears to have meant summer millet cultivation in harrowed fields in June and July, possibly involving mixed cropping to keep weeds to a minimum. Manuring and weeding may have taken place but there is no indication that this was common occurrence. Harvesting would be done in September and October, possibly followed by plowing of the harvested fields. Processing and preparing of the food grains obtained in this strategy would proceed in similar ways as for those plants obtained in the first two strategies. While millet cultivation may also have occurred in the winter under irrigated conditions, based on the present environmental

conditions, dryland farming is not only preferred but produces good yields with limited energy expenditure. The greatest advantage of dryland farming of millets is that with a limited amount of energy input, and in poor climatic conditions, some yield is always obtainable. By taking advantage of the summer monsoon rains, a sizeable crop can be obtained and easily stored for use throughout the year.

Equipped with these three strategies, the Rojdi inhabitants had a dependable plant procurement system which provided them with a significant portion of their diet. It provided them with plant food throughout the year and with the addition of herding, hunting, and fishing, a subsistence system existed which would have enabled a community the size of Rojdi not only to exist but possibly even to grow. Undoubtedly, the Rojdi plant procurement system was an open, dynamic system, evolving and changing in response to such factors as climatic changes, human impact on the local habitat, acquisition of new species and technologies, interaction with other populations, movement and growth of populations, as well as internal and external changes in the socio-cultural system. However, study of the Rojdi plant complex suggests there was a core plant-use system that was maintained throughout the occupation of the site. This type of system can be seen in figure 44, where the three different procurement strategies are presented as the main sources of the plant portion of the Rojdi subsistence.

Although this basic model is a starting point for the understanding of the Rojdi plant usage system, and may even represent a strategy common throughout the Sorath Harappan region, it does not explain the variation found in the proportions of particular species being used during different periods of occupation, nor does it explain the introduction or discontinued use of other species. Assuming that this variation represents changes in the subsistence system and is not the illusory result of biases in preservation, collection and analysis, then internal or external factors need to be examined that may have caused such a change. Most intriguing is that the time period of the most significant changes observed in the Rojdi archaeobotanical record coincides with the shift from the Mature to the Late Phase of the Harappan Civilization. Understanding the extent and possible causes of changes in plant-usage at Rojdi may therefore have implications regarding the decline of urbanism in Saurashtra. It is as yet unknown if this shift was occurring throughout the area of Harappan influence.

Figure 44. The plant-based food procurement system for Rojdi (the concepts underlying the construction of this model are derived from Harris 1977:196).



The Evolving Plant-Use Strategy

Three types of changes in the plant record over time have been observed at Rojdi; first, in the proportional relationships of the core plant complex species; second, the introduction of new species; and finally, the disappearance of other species. In general, the Rojdi seed record indicates a shift toward a more intensive and diversified plant-use strategy. Intensification of cultivation practices probably took the form of multicropping, in other words, the increased usage of cultigens grown in the winter months and needing some form of irrigation. The types of

intensification occurring at Rojdi required an increase in labor input, accompanied by a probable decline in agricultural output per unit of labor. Yet the overall advantage would have been a more dispersed, seasonal output with an overall increase in yield. Diversification at Rojdi takes the form of an increased number of species being exploited at the expense of dependence on a single plant. There are many ethnographic examples of people diversifying their agricultural practices and uses of cultigens in order to minimize economic risk (Minnis 1985b:33), though not necessarily at the same time as intensification. What is most interesting is that nearly all of the species acquired during the occupation, (e.g. Sorghum bicolor), could have been placed in the subsistence system in a tried and tested category (of both knowledge and use), and thereby be treated and used in ways that already existed. Therefore, while crop choice diversified, the basic procurement strategy remains unchanged.

The combination of an intensification of cultivation, a broadening of the plant portion of the subsistence system through diversification, and a continued pattern of crop acquisition in association with a continuing use of a general procurement strategy, form the underlying principles of change in specific plant-usage strategies at Rojdi, particularly at the point of transformation between Rojdi B and C. Since changes in the Rojdi plant record coincide with

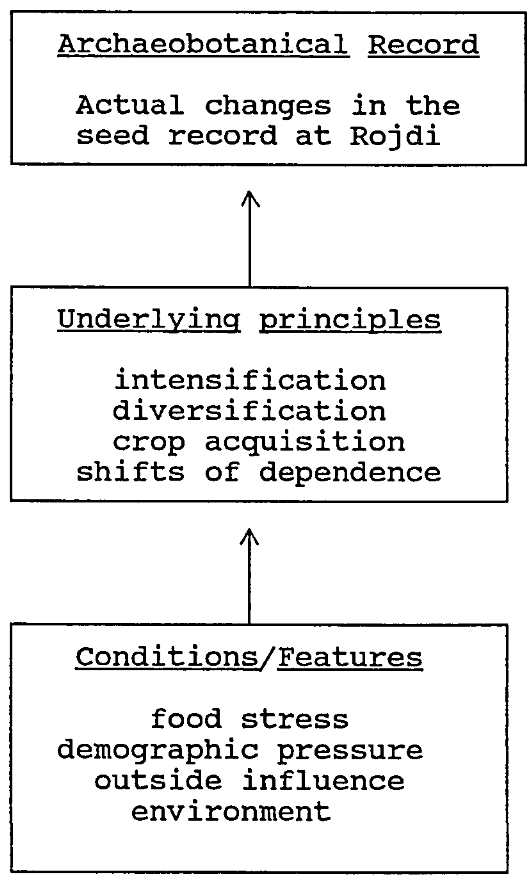
demographic shifts and changes in the material record throughout the Harappan Civilization, perhaps the changes observed for Rojdi reflect a culture-wide, rather than a purely local pattern.

Explanations for change center on three primary factors: food stress, demographic pressure, and influence from non-local populations. While all three factors could incorporate both natural/environmental and cultural variables, it is the cultural variables that are of greatest interest since there is no evidence for substantial changes in the local climate. Cultural factors are often difficult to elicit from prehistoric contexts, particularly since many cultural phenomena leave no archaeological trace. Political, ideological and socio-economic influences are thus largely absent from the discussion.

Together, the three factors mentioned can be made to account for most of the changes seen in the plant record (figure 45). Food stress emphasizes the plants as components of human diet, and the shifting choices among plants that a population must make in order to overcome food shortages; demographic stress deals with altered needs of human populations due to their changing distribution and density; outside influence incorporates both the movements of ideas, technology, or plants themselves, independently of the movements of populations, and/or with socio-economic change

occurring outside the local area, which may nonetheless impact this local area.

Figure 45. Process of explanation for the changing Rojdi seed record.



Food Stress. Food stress as a condition or factor for change at Rojdi is seen here as any type of shortage or perceived shortage in food from plants that may have caused the inhabitants to adapt or change plant usages. Food stress, in differing degrees of magnitude, is a constant focus of concern in South Asia today, and, assuming a similarity in environment, moisture pattern, plant taxa, and perhaps in the agricultural methods employed, was probably no less so 4000 years ago. Recent causes for food shortages and subsequent food stress are the result of natural occurrences such as drought, insect infestation, flooding and disease, and such culturally-induced phenomena as war, socio-political disruptions, administrative difficulties and migration (Minnis 1985b). The frequency and duration of food shortages vary. They can be divided into acute, episodic events and chronic, recurring problems (Minnis 1985b:8).

Changes in the plant use strategy at Rojdi appear to include both gradual and more sudden shifts. Diversification and intensification (indicated by the range and number of plants) seem to have proceeded gradually, while the proportions of plants, and thus relative dependence upon any given plant within the Rojdi plant complex, shifted more suddenly, suggesting the occurrence of a stressful event. If the magnitude of the change in food usage reflects the severity of the perturbation (as explained by Minnis 1985b:19), then the changes in Rojdi subsistence strategy

suggest the continued presence of food shortages or perceived shortages, and the existence of at least one instance of a more severe food stress.

Responses to food stress, while varied, usually include either economic diversification, tapping into other resources from other communities, or the use of low preference foods. At Rojdi, all three of these responses may have occurred. Economic diversification is seen in the form of broadening of the subsistence base by increasing the numbers and types of taxa exploited. The use of other resources may be seen in the acquisition of non-indigenous plants that increase in occurrence in the later phase of Rojdi. Further, if low preference foods are regarded as those species which people know they can eat, but prefer to avoid in times of normal food availability (Minnis 1985b:35), then short periods of dependence on wild species that are good substitutes for cultivated taxa may well be an example of the use of low preference food. The short-term increased usage of certain species at Rojdi, (e.g. C. album), may be explained using this idea of low preference foods.

Arguing the existence of persistent food stress is easier than explaining or theorizing the causes or processes which lead to its occurrence. Such natural processes as periodic droughts, in association with human degradation of the environment and the knowledge that the environment around Rojdi was marginal and unpredictable could help explain the

continued presence of food stress. Yet this still leaves the explanation for a more severe period of food stress open. Though possible, there is presently no indication for a major environmental shift, severe enough to cause the type of sudden change in uses of cultigens seen at Rojdi. Since these shifts cannot be attributed to natural factors, cultural factors need to be examined. This bring us to the second condition of factors, that of demographic stress.

Demographic Stress. In this work, demographic stress will be used to refer to changes in subsistence that are the result of changes in the ratio of population to resources (Harris 1977:187). It is argued here that changes in the demographic structure around Rojdi could be significant enough to result in shifts in the plant-usage strategy. Leaving aside the question of the validity of the theory that the transition from foraging to food production was a consequence of population pressures (for more detailed discussion see: Adams 1978; Flannery 1969, 1973; Cohen 1977), demographic stress can be used to refer simply to those demographic variables which may have led to a change in the use of food plants at the site like Rojdi.

The demographic variables capable of impacting Rojdi would include an increase in the number of people living at the site due to internal population growth or migration, or a restriction upon access to resources due to changing

distribution of people in the vicinity of Rojdi, but not at the site itself. In either case the result is the same, in that the carrying capacity of the food procurement system at Rojdi would be outstripped by the number of persons needing food. This could result in changes in the subsistence system.

Subsistence intensification, as it appears to be occurring at Rojdi, may be seen as a primary response to some form of demographic stress. Intensification can be seen as an increased frequency of cropping, with possibly a greater labor input per yield return. According to Boserup (1965), increased cropping generally requires more labor input while the agricultural output per unit of labor decreases. Though many of Boserup's underlying assumptions may not be applicable to the activities thought to have had occurred at Rojdi, (e.g. that farmers attempt to obtain and adequate subsistence input while maximizing leisure time), her basic supposition that population pressure (basically population growth) causes changes in land use, land tenure systems, settlement patterns, and agricultural technology, which result in agricultural intensification, may well be applicable. While the proposition that population growth is inevitable and agricultural intensification results in declining outputs per unit of labor have been extensively challenged and debated, they will not be discussed here. What is of interest is simply the relationship Boserup has

posited between agricultural intensification, multi-cropping and labor input, especially since much of her model is based on data derived from the comparison of dry land farming and irrigated agriculture practiced in India. The shift toward multi-cropping in the later levels of Rojdi may be interpreted, based on this relationship, as an increase in man-hours and yield, or an intensificaiton in cultivation activities.

Although demographic stress can be perceived as a major motivating factor for increasing or intensifying subsistence production, it may be the result of any one of a number of conditions. The most commonly stated process causing demographic stress is population growth, though climatic shifts, environmental deterioration, changing socio-economic needs, migration, immigration or any combination of these are also important variables in population size and aggregation. Environmental changes, whether induced by humans impacting the local habitat, or resulting from natural patterns of change, affect the distribution of wild plants and animals in the region and can affect the types of cultivation practiced, as well as where people live and practice agriculture. In turn, this can affect the aggregation of the population and subsequently necessitate changes in the subsistence system. By contrast, population growth and immigration increase the density of people, thereby increasing the demand for subsistence products. Changes in

the socio-economic system could result in changing distributions of the population in given locations in a region, which may affect the density of people and change the demand for food products.

Influence From Non-Local Populations. Localized food stress and demographic pressure may not be the only factors involved in causing change in Rojdi plant-usage systems over time. Influencing factors from outside Rojdi, including those from regions outside Saurashtra, may have been involved in the types of changes observed in Rojdi subsistence. The exchange of ideas and products may not only affect the processes of food production, but can affect the demand for food products. In addition, forms of food stress, demographic pressure and environmental change that may have been initiated outside Saurashtra, could have led to concomitant stresses in Saurashtra, and hence Rojdi, as redistributions in subsistence products were effected, as opposed to there being direct population movement.

The evidence at Rojdi shows that while non-indigenous plant species were continually being introduced to Gujarat, this trend increased in the late periods of occupation. At the time of this increase, major changes in settlement patterns, shifts in the material record, humanly induced ecological changes and shifts in climate and river flow patterns were occurring in regions outside Gujarat. This is

best documented in the Indus Valley, though other regions of the Harappan Civilization were experiencing similar events. Changes in other regions of the Harappan Culture which affected their need for food, could have impacted the Sorath Harappans in such a way as to be a factor in changes seen in plant-usage strategies of sites like Rojdi, without direct movements of populations into Saurashtra.

The archaeobotanical record does suggest either direct or indirect spheres of contact with populations in Africa, West Asia, East Asia, and South East Asia. The Rojdi data further suggest that based on proportions of non-indigenous species, West Asia and the North Western region of South Asia were the more important areas of contact or influence.

The Rojdi Plant Procurement System

Although the Rojdi land-use pattern remained relatively stable, factors such as demographic pressure, food stress and outside influences were impacting Rojdi and were causing changes in the Rojdi-plant interrelationship. Feedback between these variables would have further impelled change in the subsistence system. For example, once a subsistence strategy alters the environment (which is a common occurrence), the environment, in turn, can bring about changes in culture and in food-use patterns. Decisions at Rojdi to use, or not to use a plant, or to change some aspect

of the subsistence strategy, were not simply choices in order to maximize, or a simple reflex to some form of natural of social stress. There is no reason to assume people are trying to maximize their average return, for the simple reason that ideal, abstract conditions for maximization are rarely met. Obstacles to maximization include the existence of conflicting requirements in a population, or a plentiful supply of different plants that may preclude optimal exploitation of specific ones, or other, unique circumstances of history (Alcorn 1984).

Based on the archaeobotanical data available for Rojdi, and taking into account these limiting and influencing factors, a series of models representing alternative pathways via which the Rojdi plant-usage system could have changed will now be presented. These models are derived from a combination of the food procurement system presented in figure 44 and the factors and conditions affecting change as presented in figure 45. Where the model in figure 44 presents a system where a state of equilibrium is maintained by cultural controls, and exists in a physical environment with little or no change, the model in figure 46 presents an unstable system where a change in subsistence is the result of a variety of related factors.

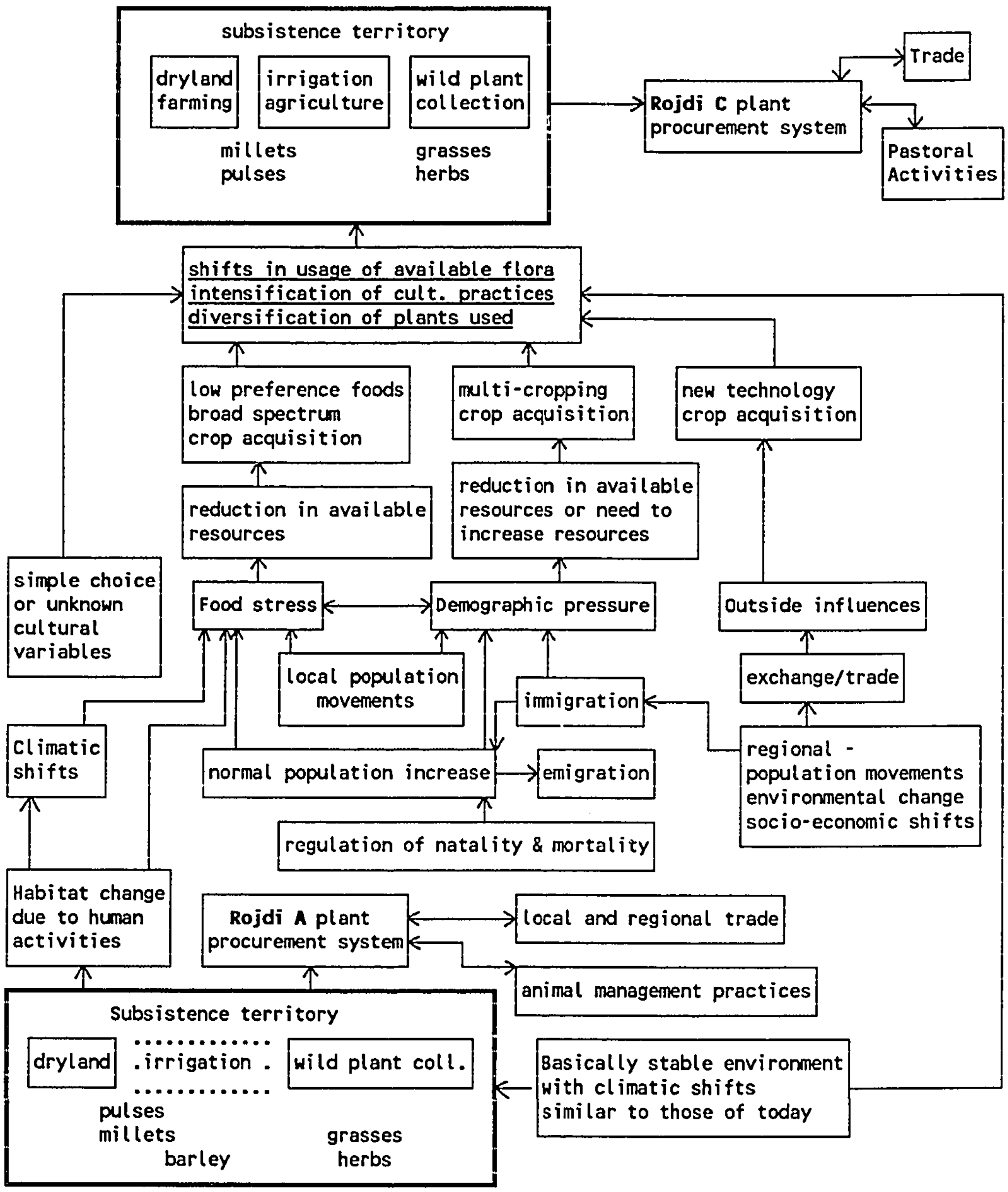
Figure 46 is a diagnostic model, which incorporates migration into or out of the subsistence territory, ecological changes, population growth and aggregation, and

trade or exchange. It assumes that these variables stimulated food stress, demographic stress or responses to outside influences, which necessitated an increase in the size of, or at least changes in, the resource base. Shifts in the usage of available flora, intensification of cultivation practices and efforts at diversifying the plant material used in their subsistence system may then have been triggered. The end result was a plant procurement system which incorporated such activities as dryland farming, irrigation agriculture and wild plant collecting, and where the plant species involved in such activities, and the activities themselves, were subject to change and variation in terms of their relative importance in the overall subsistence strategy.

These relationships are largely hypothetical. Yet the model attempts to incorporate important variables whose presence and impact can be subject to testing. Its purpose is to demonstrate the complexity of subsistence change, and to direct attention away from prime movers such as climatic change or population growth. There may be more cultural variables at work, but is hoped these can be incorporated into the model as our understanding of the site increases with the completion of the analysis of all the Rojdi material. The model acts as a basis of comparison for other sites and permits the expression of the Rojdi archaeobotanical data in theoretical and comparative terms.

The usefulness of such a measure will become apparent in the next chapter, which focuses on the significance of the Rojdi material beyond the site and its inhabitants.

Figure 46. Pathways for change in Rojdi plant procurement system.



Chapter X. <u>WIDER SIGNIFICANCE OF THE ROJDI PLANT REMAINS</u>

The Rojdi data as a whole suggests that the site was part of a regional system, actively involved with other populations. Although many of its cultural traits may well have been unique to Rojdi, its ceramic styles, building technology and foods were similar to those of other Sorath Harappan sites. Rojdi may be viewed as typical for this area, at this time period, and therefore the paleoethnobotanical study performed at this site has significance for understanding broad patterns of plant-use.

Information gained from Rojdi can be used to confirm or refute the existence of a specific, recurring complex of plants utilized at this time and within this region, test suppositions of when certain plant taxa were first used in South Asia, as well as test theories that posit a specific outcome from the introduction of new plants into an existing a subsistence system. Further, the Rojdi data, in association with all the available South Asian plant data of comparable age, enable us to evaluate and compare various agriculture practices and plant-use strategies occurring within the region associated with the Harappan Civilization, and subsequently to develop testable models which may better explain Harappan subsistence, its common elements and its diversity, and most importantly how it changes over time.

Specifically, three issues of importance for the Harappan Cultural Tradition as a whole can be approached with the addition of the Rojdi plant data. These include: crop acquisition and its impact on socio-economic systems, trans-regional systems versus region-specific plant-usage systems, and seasonality, cropping patterns and the relative dependence on plants in the diet.

Crop Acquisition and Outside Influence

The origins of plants thought to have been cultivated at Harappan settlements have been debated for some time. While the archaeobotanical remains from Harappan sites contain species which are thought to be from South East Asia, East Asia, Africa, West Asia, and South Asia itself, scholars have tended to overemphasize West Asian influence at the expense of other regions of the world (Sharma 1972:95-106). In fact, one of the most striking tendencies is to emphasize any region of the world other than South Asia itself. Other than possibly rice, all major food grains found in South Asia are not thought to be indigenous to this region. Since non-indigenous plant species play a major role in subsistence systems, the place of origin of these species and their dates of entry into South Asia reflect, and are basic to the understanding of, outside influence on indigenous cultural development.

At Rojdi, many of the plant species recovered now represent the oldest finds of such species in South Asia. They will probably eventually be found at even earlier dates as more sites are excavated with the systematic collection of archeobotanical material as an objective. Therefore, all theories which attempt to incorporate crop acquisition, or the appearance of non-indigenous species into theories of outside (non Harappan) influence, need to be re-examined.

One group of grasses, the "millets," which form a major portion of the subsistence system in South Asia today, (45 percent of all land planted to food plants), yet their origins have been continually debated (Harlan 1970, 1976, Hutchinson 1976, Costantini 1979a, 1979b). Their appearance has been associated with changes in settlement and subsistence systems (Chitalwala 1982, Possehl 1974, 1986, Jarrige 1985), and they show up prominently at the site of Rojdi. So far, the earliest occurrences of millets in South Asia date to between the Mature Phase and the Post-urban Phase. While early finds of millets in South Asia are not solely from Harappan sites, their occurrence within the regional sphere of what is considered the "Harappan Cultural Tradition" implies that millets would be best understood within this temporal framework.

Before their discovery at Rojdi, millets had been found in a variety of sites dating from the end of the third millennium through the second millennium B.C. (table 38).

Table 38. South Asian millets based on site and date of occupation.

LOCATION	DATE	ELEUSINE	SORGHUM	PANICUM	SETARIA	PENNISETUM
Gujarat	Today	*	*	*	*	*
Rojdi	2500-1800	*	*	*	*	-
Hallur	2100-1100	*	-	-	-	*
Surkotada	2200-2000	*	-	*	*	-
Daimabad	1800-1100	*	*	-	*	-
Rangpur	1700-1400	-	-	-	-	*
Ahar	1950-1500	-	*	-	-	*
Pirak	1900-1500	-	*	*	-	-
Oriyo	1700-1400	*	-	*	*	-
Inamgaon	1600-1300	*	*	*	*	-

Sorghum and Panicum sp. were recovered from reliable contexts at the site of Pirak, on the Kachi plain near Mehrgarh. The Pirak millets occur in a settlement dating to the early second millennium B.C. at around 1600 B.C. (Costantini 1979a:330). At Surkotada, grains of Eleusine, Setaria, Panicum and Enchinochloa colonum have all been recovered from the late levels (Vishnu-Mittre and Savithri 1982), dating to either the late Urban Phase or initial Post-Urban phase (Joshi 1972c). From Rangpur, bajra (Pennisetum typhoideum) was recovered in a Post-Urban context (Ghosh and Lal 1963). At the site of Daimabad in Maharashtra, Eleusine, Setaria, Paspalum and Sorghum have been found in the Malwa phase at about 1900 B.C. (Sali 1982; Kajale 1974; Vishnu-Mittre 1977). Sorghum has also been retrieved in the Malwa phase (1600 B.C. to 1300 B.C.) slightly further south in Peninsula India at the site of Inamgaon (Vishnu-Mittre 1970). Also from this

site are Eleusine, Panicum and Setaria (Kajale 1974, 1988b). In the initial habitation levels of the Neolithic site of Hallur, dating to about 1950 B.C., Eleusine and Kodo millet (Paspalum scrobiculatum) were recovered (Vishnu-Mittre 1971). From the Neolithic-Megalithic transition phase at Hallur, bajra has also been found. At Ahar, in Rajasthan, impressions of grains of bajra, Sorghum and possibly Kodo millet were all identified (Vishnu-Mittre 1969). The sherds in which these impressions were found date from 1725 to 1270 B.C. Finally, based upon my own observations, charred seeds from Oriyo, in central Gujarat, can be identified as Eleusine, Panicum, and Setaria. The Oriyo material is considered part of the Lustrous Red Ware, Post-Urban Phase (Rissman 1985).

Based on limited archaeological data, as well as linguistic information and comparisons of morphological and genetic features of modern samples of millets, a number of hypotheses have been developed to explain where these millets came from, the time at which they appeared, and what their influence was on the cultural development of South Asian populations and specifically, the Harappans. Three possible centers of origin appear in the literature (published over the last 100 years) for the millets used prehistorically in South Asia.

1. African center of origin.

   Sorghum (Dogget 1970; Harlan 1976; De Wet and Harlan 1972).

   Eleusine coracana (Mehra 1963; Hilu et al. 1979; Savithri and Vishnu-Mittre 1979).

   Pennisetum typhoideum (Hutchinson 1976; Vishnu-Mittre 1976).

   Panicum (Government of India 1966:223).

2. East Asian center of origin.

   Panicum (Wirth 1937; Vavilov 1951; Ho 1975).

   Setaria (Rao et al. 1987; Wirth 1937).

3. South Asian center of origin.

   Sorghum (Wirth 1937; De Condolla 1884; Vavilov 1951).

   Eleusine coracana (Wirth 1937; Chandal 1959; Mann 1946; Dixit et al. 1987).

   Paspalum scrobiculatum (Hutchinson 1976).

   Panicum (Chalam and Venkateswarlu 1965).

At the present, there appears to be a consensus that _Sorghum_, _Eleusine_, and _Pennisetum_ are all of African origin and were probably brought to India by the beginning of the second millennium B.C. (Weber 1988). It has been suggested that these crops were moving within an interactional sphere involving the Indus Valley and the Persian Gulf, and that the arrival of "African millets" coincided with an increase in

sedentism and agriculture in peninsular India (Possehl 1974, 1986:237-250, Hutchinson 1976). According to this theory, the founding of village farming communities in areas like Gujarat had been a "marginal option" at best as long as wheat and barley were the only available cereal grains (Possehl 1986:249). Once a set of cultigens, well adapted to a summer growing season based on the summer monsoon, was integrated into the subsistence regime, there was an explosion of village farming communities. Millets may have been just such cultigens. The date of this explosion has been hitherto associated with the Post-Urban Phase, yet some recent excavations have pushed the dates of some of these communities earlier, suggesting that this increase in settlements may be more closely associated with the Urban Phase between 2500 and 2000 B.C. (Possehl and Raval 1989).

The use of millets has also been identified as part of an agricultural system/settlement pattern shift in the North Kachi Plain at the beginning of the second millennium B.C. (Jarrige 198:35-68). Using archaeobotanical remains from the sites of Mehrgarh, Pirak and Nausharo, as well as inferences from artifacts, and location, distribution and size of sites in Baluchistan, Jarrige (1983) suggests that changes in the socio-economic system occurred in this region at about 2000 B.C. According to his theory, an increase in population and a denser network of villages and towns produced environmental degradation, (overgrazing, monocropping, and overwatering led

to salinization); as a result, the agricultural system added permanent irrigation systems, multicropping, and exploitation of marginal areas not suited to wheat and barley with new crops (millets, sorghum, rice), and a general increase in labor investment associated with an intensification of land use (Jarrige 1985). A shift from flooded field cereal cultivation of wheat and barley during the winter months to a multicropping strategy involving summer cultigens, as well as the standard winter ones, and a shift wherein cattle begin to decrease in favor of sheep and goats, are the significant changes thought to occur at about 2000 B.C. It is further suggested that no sudden drop in agricultural productivity nor sudden influx of refugees is related to this transition (Jarrige 1985).

With the addition of sites like Rojdi where millets occurred in abundance and where an in-depth analysis of millets was conducted, we gain an enhanced picture of this category of plants in prehistoric South Asia. Four millets were found in significant amounts at Rojdi and are relevant to the ideas stated in these theories: *Eleusine coracana*, *Setaria italica*, *Panicum miliare*, and *Sorghum bicolor*. The dates of these four millets in the Rojdi record are as early as any recorded for South Asia, and in all four cases may be the oldest so far found in this region.

The presence of *Eleusine* from the earliest levels of Rojdi suggests that if these plants came from Africa, there

was direct or indirect contact with African populations prior to 2600 B.C. This date is significant in that it implies that communities in Gujarat (with Harappan-like artifacts) were cultivating millets during the Urban Phase, hundreds of years prior to the time when the so-called Post-Urban expansion or increase in village farming communities found in Saurashtra, is thought to have occurred. This may imply either that the village expansion was not causally related to the appearance of Eleusine, or it may support the recent argument that what has been identified as the Post-Urban expansion was in reality a shift in regional settlements during the Urban Phase, in which Eleusine may have had some role to play. On the other hand, if Eleusine is subsequently found at an even earlier date in South Asia, as is not inconceivable, it will be difficult to associate the appearance of this food grain in South Asia with a shift in settlements, although any change in the proportions of Eleusine may turn out to be significant.

The presence of Eleusine at Rojdi is also interesting in that if it arrived overland from Africa, then how do we account for the lack of archaeobotanical evidence of African millets in Baluchistan prior to 2000 B.C.? Either Eleusine entered Gujarat by the sea route and then moved northward or it went through portions of Baluchistan and the archaeobotanical data has yet to be found. In either case, the existence of millets at Harappan sites does suggest that

the arrival of African cultigens was earlier than previously believed and that it needs to be taken into account in interpreting Harappan subsistence and subsequent changes in that system.

Sorghum, by contrast, is absent in the early levels of occupation at Rojdi, yet is recovered in the upper levels, implying its introduction into Rojdi after 2000 B.C. Since it is almost certainly of African origin, yet in the Rojdi record it is found in levels after the occurrence of Eleusine, it suggests that Sorghum may have entered South Asia independently of Eleusine implying either a continuous or multiple periods of interaction with people in Africa or with people who had contact with African populations. It is interesting to note that the occurrence of Sorghum in the Saurashtran subsistence system coincides with its proposed introduction into Baluchistan.

Setaria italica recovered in the earliest strata of Rojdi can be placed within 400 years of the oldest finds of domesticated Setaria anywhere else in the world, including those in the highlands of Central China from the Yang-Shao culture, some 5000 years old (Rao et al. 1987). The origin of Setaria italica is thought to be less certain than that of the African millets. Though the early dates suggest an indigenous origin, taxonomists have yet to identify a wild ancestor growing in South Asia. The present consensus seems to be leaning toward East Asia as a center of Setaria

domestication. The debate about its origin and its movements across Asia are similar in many ways to those concerning rice. Early finds of both species are often associated with pottery temper impressions from sites in similar regions and environments and the increased dependency on these species occurs at similar time periods. It may be that Setaria entered South Asia in the company of rice (Whyte 1985), or simply the domestication of one species is in some way associated with the other.

Regardless of whether Setaria was first domesticated in East Asia or somewhere in South Asia, its occurrence at Rojdi and the apparent increased use of this species at this site, still needs to be interpreted in the context of South Asian (Harappan) subsistence practices. The appearance of this plant at Rojdi may be approached in several ways. Either, as with the African millets, there was a second sphere of interaction, this time to the north east of South Asia, contemporary with the one in the west. Or, the indigenous management of Setaria leading to its domestication was going on at the same time as interaction with peoples to the west. Since Setaria appears in South Asia as early as any millet, yet does not become a prominent plant in the archaeological record until the Post-Urban or Late Harappan phase, then shifts in the usage of this species may indeed be associated with more general socio-economic demographic shifts occurring around 2000 B.C.

While a number of different species of *Panicum* were recovered at Rojdi, *P. miliare* was by far the most dominant. While suggested places of origin range from South East Asia to East Asia, it is highly probable that it is indigenous to South Asia. Its occurrence at the early levels of Rojdi (2500 B.C.) and the existence of wild species found growing in South Asia, help support this view. If the occurrence of *Panicum miliare* at Rojdi represents the cultivation of plants indigenous to South Asia as early as 2500 B.C., then plants need not have been introduced from other regions of the world in order for farming communities to develop.

The detailed information gained from the Rojdi millets can help fill out a more general South Asian subsistence picture. Millets do seem to have played a major role in the food economy of some prehistoric communities in the subcontinent, and their distributional variation over time implies that a more complex relationship existed between the occurrence of millets and changing subsistence and/or settlement patterns than previous theories have tended to assume. Further, it should be understood that millets are only one category of plants around which debates over origin and outside influences have centered, and are discussed here as an example of the need to be cautious in assuming a direct causal relation between the appearance of plant taxa and significant changes in settlement and subsistence changes.

Trans-regional vs. Region-specific Subsistence Systems

All subsistence systems are constrained by the environment. Such factors as moisture patterns, temperature range, and soil type must have been a limiting factor on the types of plants being exploited. Since different environmental features favor different plants, various regions of the Harappan civilization were more suited to the cultivation of certain species than other regions (figure 7 and 8). As is seen in table 39, spatial variation presently exists in the archaeobotanical record, yet this variation is in part due to the limited data base, the method of data collection, the lack of proportional representation, and the various periods of occupation being grouped together (all reasons discussed earlier). Therefore, what can be said regarding regional subsistence variation?

The most likely trans-regional food plant is barley, which appears in most Harappan sites. While barley is often found in large volumes, its proportional value or use is known in only a few sites. At Rojdi, where a wide range of species were recovered, only a few grains of barley occurred.

Table 39. Cropping season of main food plants recovered in archaeological sites according to region and site of occurrence.

CROPS	SEASON	REGION/CATEGORY A	B	C	D	E	F	G	H	I
CEREALS										
Wheat	Winter	*	*	*	*	*	*	*	*	*
Barley	Winter	*	*	*	*	*	*	*	*	*
Rice	Summer	-	?	-	*	*	*	-	*	*
Millets	Summer	-	-	-	*	*	*	-	*	*
LEGUMES										
Peas	Winter	-	-	*	*	*	*	-	*	*
Lentils	Winter	-	-	*	*	*	*	-	*	*
Gram	Summer	-	-	*	*	*	*	-	*	*
OILSEED/ FIBER										
Linseed	Winter	-	-	-	-	*	*	-	-	*
Mustard	Winter	-	-	*	*	-	*	-	*	*
Sesame	Summer	-	-	*	-	-	*	-	*	*
Cotton	Summer	*	-	*	-	-	-	*	*	-
FRUIT										
Melon	Summer	-	-	*	-	-	-	-	*	-
Date	Variable	*	-	*	-	-	*	*	*	*
Jujube	Winter	*	-	*	*	*	*	*	*	*
Grape	Variable	*	-	*	-	*	-	*	*	*

A - Indus Valley core area - Pre-Harappan
B - Peripheral areas in Harappan territory - Pre-Harappan
C - Indus Valley core area - Mature Harappan
D - Peripheral areas in Harappan territory - Mature Harappan
E - Indus Valley core area - Late Harappan
F - Peripheral areas in Harappan territory - Late Harappan
G - All Harappan and Harappan-like sites in all areas - Pre-Harappan
H - All Harappan and Harappan-like sites in all areas - Mature Harappan
I - All Harappan and Harappan-like sites in all areas - Late Harappan

Its occurrence at Rojdi suggests that while the inhabitants did have access to barley, it was not the preferred food plant. Millets were the dominant cereal grain at Rojdi, a plant better suited to the environment of Saurashtra. This would seem to support the idea that there was a preference for species better adapted to the habitat around the settlement. While no specific trans-regional crop complex emerges from the limited archaeobotanical record based on recurring plants in all Harappan sites, in each region of the Harappan Civilization a small number of species do recur. While their proportional usage is unknown, at least some remains of barley, peas, and mustard have been recovered from all regions of the Harappan civilization.

A number of more localised patterns are also implied by the available data, although these may be confirmed or become less distinct with the addition of new sites. In Gujarat, millets show up in all Harappan sites where large numbers of botanical remains were recovered. In Sind and the Punjab, wheat has been found in all Harappan sites containing archaeobotanical remains. Also, cotton has been identified in the large sites of Baluchistan, Sind and the Punjab. Other than these minor trends, few plant species recur in all sites within a given sub-region of the Harappan tradition. However, it is likely that local patterns are occurring and are hidden by the simple lack of data which is often wrongly used as negative data. Evidence from Rojdi implies this may

be the case, and in addition suggests the range of species available to a community is much greater than is generally believed, and that a variety of plants were being cultivated at different seasons.

Seasonality, Cropping and Relative Dependence On Plants

While structural and artifactual remains found in Harappan sites imply that they were generally occupied throughout the year, seasonal activities involving various agricultural practices are more difficult to determine. The identification of species best grown at certain times of the year is one of the best indicators of seasonality. Knowledge of the season or seasons of cultivation, and whether single or multi-cropping was part of their subsistence strategy, influences assumptions about labor involvement, the types of water management systems needed, and on the dependability and availability of plant resources. While the generally accepted description of Harappan cropping has been, as Jarrige puts it, a "system of winter crops well adapted to flood irrigation" (Jarrige 1985:45), some scholars suggest that Harappans utilized multi-cropping systems (Allchin 1969:260, Fentress 1984:365). To a great extent, integration depends on how the archaeobotanical record is used. If one uses sites from only certain regions, or sites that were occupied only at specific periods of time, then it is easy

to argue one position over another. If archaeobotanical material from all sites in which there are some elements of Harappan culture, and where the occupation coincides with some phase of the Harappan Civilization (2500 to 2000 B.C.) is tabulated together, then Harappan subsistence strategy appears to involve cropping during both the winter and summer seasons (see "A" in table 39). In contrast, if only the large Harappan settlements found within the Indus Valley and occupied during the Mature Urban Phase are examined, the subsistence strategy seems focused on winter cultivating practices.

Just as regional variation in cropping-seasons has been elicited from the data, so can variation over time be observed. Within each region a transformation from a single-cropping pattern to a multi-cropping system has been identified (for example, see Jarrige 1985:35-68). The isolation of a temporal shift in cropping pattern depends on which sites are studied, from where they were found, and on whether they are truly representative of a region-wide cropping pattern. In order to support such a contention, systematic analysis of sites with archaeobotanical remains showing this shift in cropping pattern, are required. To date this evidence rather limited.

Evidence from Rojdi suggests that both winter and summer cultivation could well be occurring at the site in 2500 B.C., and that a shift toward a greater dependence on a multi-

cropping system may well have happened during the latter portion of the Harappan era. This shift may well be related to a change in water management practices as well as agricultural techniques, and may be the cause, or the effect of changes in population and settlement patterns. The Rojdi data implies that throughout the Harappan Civilization, crops associated with different seasons of cultivation were available to most communities. Therefore, if multi-cropping was not occurring in a given region at a specific site, it was not due to the unavailability of either summer or winter cultigens.

A major point of concern in understanding Harappan subsistence regimes is the relative dependence on plants in comparison to animals, and on domesticated or cultivated taxa in comparison to wild and gathered species. The importance of herding, hunting, plant gathering and cultivation, and the relationship of each to the others, is difficult to ascertain for any single site, let alone for the Harappans as a whole, though the archaeological evidence does suggest that all four activities were occurring throughout the area of the Harappan Cultural Tradition.

Attempts to describe the relative importance of any of these activities in Harappan subsistence have related them to settlement distribution, socio-economic systems, socio-political systems and even the decline or fall of the Harappan civilization. Seal depictions of cattle, settlement

layout and distribution, climatic conditions and limitations, figurines and faunal evidence, suggest that cattle played a unique role in Harappan culture. Yet the proportional relationship between herding and cultivation, inferred from faunal and floral remains from archaeological sites, does not support this perception.

At present, the data base is minimal and would suggest that the determination of the proportional roles of the exploitation of plants and animals is in need of a great deal of work. However, describing the Harappans as agro-pastoralists may be at this time the most accurate portrayal of their food economy, since plants and animals both played significant roles (Shaffer 1986, 1988). With the example of work at sites like Rojdi, where both faunal and floral material was well preserved and collected in a systematic manner, efforts can be made to study the proportional relationships of plants and animals within individual sites. This in turn establishes the foundation upon which regional pictures can be constructed. At the time of writing, the Rojdi faunal material awaits analysis and cannot contribute to this task at this time. In conclusion, it is difficult to state more about the structure of subsistence activities beyond Possehl's characterization of "... an integrated system within which both animal and plant produce was generated and consumed," (Possehl 1977:539).

The relative importance of wild, collected plant matter compared to cultivated material is only slightly better understood. The proportion of gathering to cultivating is important in determining the dependability of the diet, the energy involved in obtaining a suitable amount of food, the types or range of necessary social structure, the impact on the habitat, the required technologies, and vulnerability to various forms of food stress or demographic pressures.

In most dietary reconstruction of Harappan subsistence practices (Fairservis 1967), the focus is on cultivated plants (Vishnu-Mittre and R. Savithri 1982:205-222) though reference to plant gathering has not been completely ignored (Vishnu-Mittre 1985:281-292). Yet, since most plant occurrences in Harappan sites represent accidental finds, little can be said other than both gathering and cultivation were important to the Harappan civilization. The archaeobotanical remains from Rojdi suggest that while cultivated species represent the majority of the recovered remains, wild plant gathering accounted for nearly one fourth of the plant food. While this relatively high usage of wild species may be unique to Rojdi or to peripheral Harappan sites in general, it does suggest that at the time period in question, cultivation was by no means the sole source of plant food.

One Possible Way To View Harappan Subsistence

I have consistently argued that the available archaeobotanical database for the Harappan cultural tradition is extremely limited, yet it is not impossible to use it to suggest some tentative views about Harappan subsistence patterns. These patterns are based on the tabulation of the archaeobotanical data from all Harappan and Harappan-like sites located in the northwestern portion of South Asia. The computer analysis and tabulation of this data attempted to take into consideration such variables as method of excavating, and collection of the archaeobotanical material, the value of each site's plant remains, and attempts to limit the use of negative data from sites which lack systematic collection and analysis. Following these lines the Harappan archaeobotanical record can be most safely understood according to when particular species first appear and are therefore available, and according to which regions within Harappan territory these species are found.

The general picture can be summarized as follows. Based on all Harappan and Harappan like sites, six commonly cultivated taxa are found in the Early-Harappan Phase with an additional 11 occuring by the Mature Phase or by 2600 B.C. (table 40). While few new taxa are found in the Late-Harappan Phase (four millets), detailed analysis within individual sites have shown shifts in the dependence on

existing species (e.g. the Rojdi millets). All taxa found in previous phases continue to be found in later phases and basically all species commonly used as a starch in South Asia today were in existence within this region by 2000 B.C. (the major exceptions being corn and potato). While at some sites there is a definite suggestion of relative dependence on certain species over others, so few sites contain this type of information there is no way at present to know if these patterns represent transregional, region-wide, or site-specific patterns.

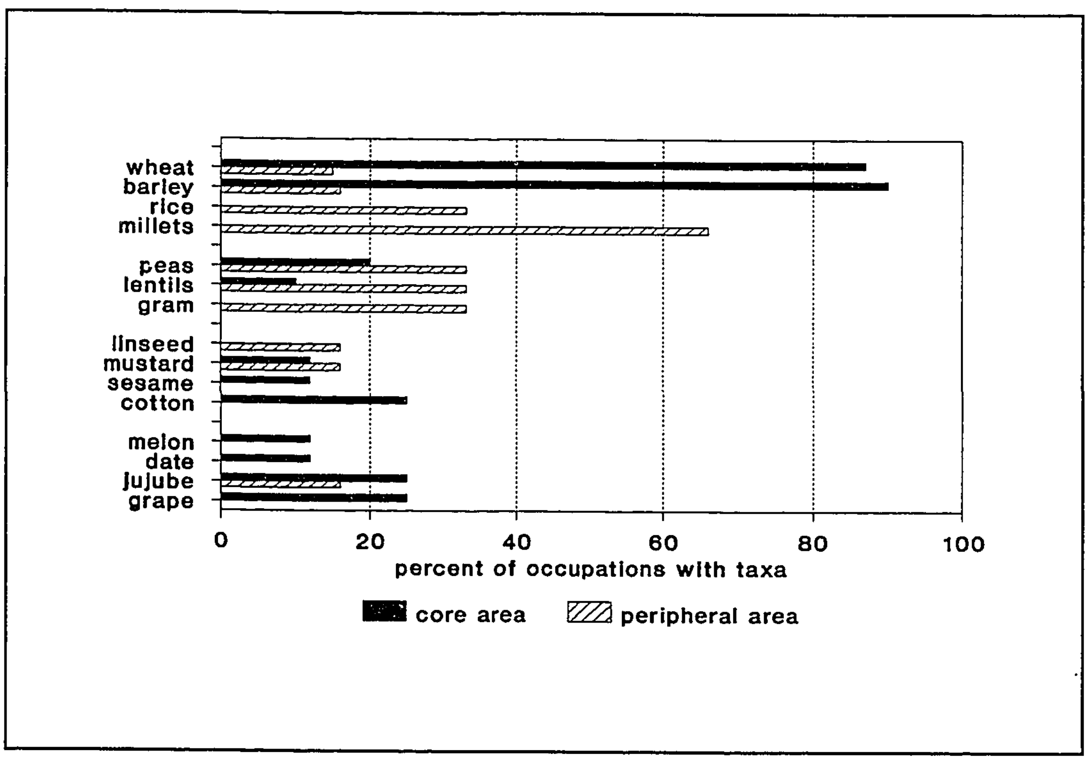
Table 40. Time of first occurrence of South Asian crop plants.

EARLY	MATURE	LATE
Wheat	Rice	Millets
Barley	Millets	Paspalum
Oats	Eleusine	Enchinochloa
Date	Setaria	Sorghum
Grape	Panicum	Pennisetum
Jujube	Peas	
	Lentils	
	Gram	
	Sesame	
	Mustard	
	Cotton	
	Melon	

If the temporal occurrences of these taxa are further distinguished according to whether they are in the core area (basically Indus Valley sites) or in peripheral regions like Gujarat, some regional distribution does appear (figure 46).

During the Mature Phase regional differences appear more acute, with few fruits, oilseed or fiber found outside the core area, and rice, millets and most legumes found more commonly in the peripheral regions. By the Post-Urban Phase regional variation seems to have declined, in that most taxa are found occurring in most regions. Yet this pattern could be the result of a 50 percent increase of Post-Urban sites containing archaeobotanical material.

Figure 47. Main crop plant occurrences in Mature Harappan Phase.



Based on our knowledge of these taxa, a number of points regarding Harappan plant-use strategies can be made. It seems safe to assume that a variety of crop plants were available and being used, and that a sophisticated cultivation strategy was in existence at the beginning of the Mature Phase that continued into the Late-Harappan Phase. Based on the environmental parameters within which these plants can flourish, the climate was not that different from today. Moreover, given the seasonal usages of these plants today, both summer and winter cultivation were probably being practised in most regions from 2600 B.C. onward, although different regions may well have emphasized one season over another. Where inhabitants of Gujarat probably depended mostly on summer cultivation, Indus valley populations depended mainly on winter crops like wheat and barley.

Although indigenous plants were being used, the focus of farming activities appears to have been initially on both indigenous and non-indigenous species, with an increased reliance in later periods on indigenous taxa. Further, wild plant taxa appear to be continually used and new non-indigenous species are constantly appearing. Though there seems to be a greater emphasis on plants with origins in Africa or Western Asia, there is ample evidence for plant borrowing from East Asia and South East Asia. Finally, the appearance of a number of new taxa at about 2000 B.C. implies a number of changes were taking place which affected existing

subsistence systems -- unless, as I mentioned earlier, we find out that the increased number of sampled sites in this time period has skewed our picture of plant utilization. Associated with these changes is a probable intensification of farming practices and a broadening of the subsistence base. Further, while localized patterns of plant usage existed during the Urban Phase, there appears a more uniform region-wide pattern of plant exploitation in the Late Harappan/Post Urban Phase. And, as stated before, most of the plants being exploited in South Asia today have been identified in South Asia as early as 2000 B.C.

Chapter XI. CONCLUSION

As pointed out in the introduction the purpose of this research project was basically two-fold. First, to look at a single site and answer a series of question about subsistence and the local human-plant interrelationship. And second, to apply the knowledge from this site and from an evaluation and summation of the archaeobotanical record for the region as a whole, to a more general synthesis of Harappan plant-usage strategies and their evolution over time. As with many research projects, the end result in reality leads to nothing more than a new series of questions. This seems to be the case here, where the main conclusions are simply a series of questions and hypotheses which now need to be tested. These questions are directed toward where I see the study of local, regional and Harappan subsistence research headed. With this in mind, the following conclusion will include a brief review of my original hypotheses and questions, with a summary of the resulting conclusions, followed by a list of new hypotheses.

Rojdi

It was initially suggested that through the appropriate methods of soil collection and the analysis of their botanical content it would be possible to document the Rojdi

inhabitants utilization of cultivated and wild plant taxa and to examine variability and change in that utilization. It is further suggested that this form of analysis will provide information on the habitat and therefore be helpful in identifying and differentiating all human and naturally induced changes occurring in the environment during the occupation of the site.

The data suggests that the habitat at Rojdi was not that different from what is seen in contemporary Saurashtra, since nearly all the species recovered from Rojdi occur today in this region of Gujarat and grow well in an environment within the range of extremes recorded for Gujarat during the last 100 years. There does not seem to have been a change in climate dramatic enough to affect either the local plant community or subsistence in general. The shifts in the subsistence system and local environment that have been observed through the Rojdi occupation were the result of more complex processes, and the increase in weedy species and decrease in arboreal pollen imply deforestation and degradation of the habitat due to human action.

Since the faunal material from Rojdi is still in the process of analysis, reconstruction of subsistence has focused solely on the plant portion of the diet. In all, nearly 80 different plant species were identified from Rojdi. Of these taxa, only a small number were found in all phases of occupation (Rojdi A, B, and C) and in amounts or in

densities which imply significant usage of the plant. A general plant-based subsistence system can be identified at Rojdi, which is maintained throughout the Harappan portion of the occupation. In this system, Rojdi was a food producing settlement occupied throughout the year where cultivation, the use of domesticates, and various pastoral activities were being performed locally, and where, to a lesser extent, plant gathering and hunting were also being practiced. The bulk of cultivation was centered on the summer monsoon and involved millets, although winter cultivation increased in importance during the occupation. In addition, the plants being exploited never needed intensive human involvement and were all hardy, drought-resistant species.

However, while the basic elements of the general subsistence system remained unchanged, some significant shifts in the plants and their distributions, expressed chiefly in the form of altered dependence on existing species, can be observed through the occupation. These shifts suggest that there was an effort to deal with some form of stress which resulted in a broadening and an intensification of plant-usage strategies.

Many plants being used at Rojdi came from outside South Asia, although some indigenous species, including cultigens, do show up. The introduction of non-indigenous species into Rojdi indicate periodic or continuous interaction with people

outside, or with intermediaries who had contact with non-South Asian populations.

Finally, it should be noted that there are no signs of food stress just prior to the abandonment of Rojdi, ruling out at least one immediate cause of its decline.

The Wider Significance of the Rojdi Data

The results of the Rojdi analysis, in association with the archaeobotanical record from other Harappan sites, permit theories dealing with plant origins, movements, and related population and settlement dynamics to be more properly evaluated.

The common elements of Harappan subsistence that can be tentatively identified throughout the region of the Harappan tradition include the following. A wide range of plants were probably being exploited by the Harappans, including cultivated taxa and gathered varieties. There is evidence that from any site where a large enough collection of plants exists, the cultigens include cereal grains, (generally barley), pulses, oil-yielding plants, and fiber plants (generally cotton). Multi-cropping and water management could easily have been employed in most regions, and in most time periods, although differentiation between regions in this respect is probably due to diverse environmental factors (as we see, for example, in the earlier phases of Rojdi).

While a sophisticated cultivation strategy was in place at the beginning of the Urban Phase and continued through the late Post-Urban phase, a number of significant changes appear to have taken place as one phase gave way to the next, including a broadening of the plant base, and an intensification of cultivation practices. Both indigenous and non-indigenous species were being exploited, and no major subsistence shift should be solely associated with the acquisition of any non-indigenous taxa.

As was observed at Rojdi, since many of the shifts seen in the dietary patterns are associated with taxa which were already available and not noticeably better adapted to different environments, changes in environment are unlikely to be the sole cause for changes in subsistence system. There is also evidence for human induced changes in the habitat around many sites that might have impacted farming practices.

New hypotheses and suggestions for further work

The analysis of the archaeobotanical material from Rojdi suggests some lines of inquiry which deserve further investigation. These can be expressed as a series of hypotheses that need to be tested for Rojdi itself, for the region of Saurashtra, and for other regions of the Harappan civilization. These hypotheses include the following:

1. The types of archaeobotanical distribution implying changes in the dietary patterns over the duration of the Rojdi occupation should continue to appear as remaining areas of the site are excavated.

2. Based on the Rojdi material, Sorghum and Eleusine entered South Asia at different times, which in turn implies that either continuous or multiple periods of interaction with people in Africa, or with people who had contact with African populations existed. If we are to tell whether this pattern repeats itself throughout South Asia, other sites need to be found which corroborate the Rojdi evidence.

3. Plant use at Harappan sites should include both wild and cultivated species. Some of the species cultivated in South Asia are indigenous to this region of the world (e.g. Panicum, jujube, gram), and that since these species appear in the archaeobotanical record as early as any South Asian cultigens, it is proposed that plant species need not to have been introduced from other regions of the world in order for farming communities to have developed.

4. It is proposed that Setaria sp. occurred in South Asia as early as any of the millets, but that it did not become a prominent cultigen until after 2000 B.C. Therefore, if S. italica is found in sites in South Asia prior to 2000 B.C.,

its proportional representation in that site should imply only minor dependence on this species.

5. The marked variation in the pattern of millet occurrences at Rojdi, the apparent shift in the kinds of millets appearing, and their distribution in successive levels suggests an alteration in millet subsistence that will be repeated in other sites in the region. This shift should be associated with changes in settlement and subsistence patterns during the beginning of the second millennium B.C., rather than with the mere appearance of millets as a set of cultigens facilitating farming practices.

6. As more sites are excavated in a manner in which more precise archaeobotanical information is obtained, the existence of a general Harappan subsistence system will be confirmed. Just as Harappan material culture displays the co-existence of common, region-wide traits and regional variants, so localized plant-usage strategies will be seen to accompany recurring aspects of subsistence practice.

7. The observation at Rojdi of plants hitherto thought to have occurred later in South Asia will be repeated at other sites in the north west portion of the sub-continent. Models of the emergence and development of Harappan culture that currently use the later dates of plant species will have to

be revised as more species are found occurring earlier dates in South Asian sites.

8. The alteration in plant-usage seen at Rojdi during the shift from the Urban Harappan to Post-Urban or Late Harappan phase will be repeated at sites, but may involve different taxa. In any case, these changes are related to diet and are part of an attempt to broaden the plant-base and intensify cultivation efforts. It is believed that this pattern of diversification and intensification will show up in the core areas as well as the peripheral ones, in any site that spans the time from the middle of the third millennium to the middle of the second millennium B.C. Corresponding to these processes of changes, there may be an increasing consistency and homogeneity in the plant base throughout the Harappan tradition. However, the possibility that this apparent increase in homogeneity merely reflects the existence of a larger database for these later periods, (which a larger database for the earlier periods might refute), should be given equal consideration in future studies.

9. Changes in plant-usage are not thought to have been caused solely by shifts in climate. While a significant level of human-induced deterioration in the environment is to be expected, environmental change and degradation is an

insufficient cause of subsistence change, for which other cultural influences need to be identified.

10. In general, the Harappans were using a wider range of plants than is presently acknowledged, and with continued work, the list of cultivated and gathered species associated with Harappan sites will grow.

These hypotheses can be tested using the types of methods outlined in this dissertation. If in the course of investigation any of these proposals are invalidated, we shall only have added to our knowledge and increased the level of certainty with which we make statements about Harappan plant-use and subsistence. Further, it is only upon the basis of critical study of the existing database, combined with more palaeoethnobotanical analyses of the kind conducted at sites like Rojdi, that good hypotheses can be made about Harappan subsistence, that can, and should be, tested by further work. Giving serious consideration to Harappan plant-use, and according it greater analytic significance that it has enjoyed in the past, will help us understand not only Harappan subsistence strategies, but more about the Harappans as a whole. It is to this ongoing project that the current dissertation is dedicated.

BIBLIOGRAPHY

Adams, K. R. 1980. Pollen, Parched Seeds and Prehistory: A Pilot Investigation of Prehistoric Plant Remains from Salmon Ruin, a Chacoan Pueblo in Northwestern New Mexico. East New Mexico University:Contributions in Anthropology No. 9.

Adams, R. McC. 1978. "Strategies of Maximization, Stability, and Resilience in Mesopotamian Society, Settlement, and Agriculture." Proceedings of the American Philosophical Society. 122:329-35.

Agrawal, D. P. 1982. The Archaeology of India. Scandinavian Institute of Asian Studies Monograph Series 46:

Agrawal, D. P. 1988. "The Harappan Legacy: Break and Continuity." Paper presented at in the Lecture Series The Indus Civilization: The Earliest History of India and Pakistan. University of Pennsylvania, September-November 1988.

Agrawal, D. P. and Datta, P. S., Z. Hussain, R. V. Krishnamurthy, V. N. Misra, S. N. Rajaguru, and P. K. Thomas. 1980. "Paleoclimate, Stratigraphy and Prehistory of North and West Rajasthan." Proceedings of the Indian Academy of Sciences. 89(1):51-66.

Agrawal, D. P. and Pande, B M. (eds.) 1977. Ecology and Archaeology of Western India. Delhi:Concept.

Agrawal, D. P. and Sood, R K. 1982. "Ecological Factors and the Harappan Civilization." In: G. L. Possehl. (ed.) Harappan Civilization. Delhi:American Institute of Indian Studies. pp. 223-52.

Alcorn, J. B. 1984. Huastec Mayan Ethnobotany. Texas: University of Texas Press.

Allchin, B. 1972. "Hunters or Pastoral Nomads? Late Stone Age Settlements in Western and Central India." In: Man, Settlement and Urbanism. (P. J. Ucko, R. Tringham and G. W. Dimbleby.) eds. :pp. 115-20. London:Duckworth.

Allchin, B. 1977. "Hunters, Pastoralists, and Early Agriculturalists in South Asia." In: J. V. S. Megaw. (ed.) Hunters, Gatherers, and First Farmers Beyond Europe. :pp. 127-44. Leicester:Leicester University

Allchin, B. 1979. "Stone Blade Industries of Early Settlements in Sind as Indicators of Geographical and Socio-Economic Change." In: M. Taddei. (ed.) South Asian Archaeology 1977. :pp. 173-211. Naples:IsMEO.

Allchin, B. (ed.) 1984. South Asian Archaeology 1981. Cambridge:Cambridge University Press.

Allchin, B. and Allchin, F R. 1982. The Rise of Civilization in India and Pakistan. Cambridge:Cambridge University Press.

Allchin B, and Goudie, A. 1971. "Dunes, Aridity and Early Man in Gujarat, Western India." Man. 6:248-65. Press.

Allchin, B. and Goudie, A. 1978. "Climatic Change in the Indian Desert and North-West India during the Late Pleistocene and Early Holocene." In: W. B. Brice. (ed.) The Environmental History of the Near and Middle East Since the Last Ice Age. :pp. 307-18. New York:Academic Press.

Allchin, B. and Goudie, A. and K. Hegde. 1978. The Prehistory and Palaeogeography of the Great Indian Desert. New York:Academic Press.

Allchin, B. and Hegde, K and A. Goudie. 1972. "Prehistory and Envrionmental Change in Western India." Man. 7(4): 541-64.

Allchin, F. R. 1969. "Early Cultivated Plants in India and Pakistan." In: P. J. Ucko and G. W. Dimbleby. (eds.) The Domestication and Exploitation of Plants and Animals. Chicago:Aldine. pp. 323-29.

Allchin, F. R. and Joshi, J. P. 1970. "Malvan: Further Light on the Southern Extension of the Indus Civilization." Journal of the Royal Asiatic Society. :21-28.

Asch, D. L. and N. A. Sidell. 1989. "Archaeological Plant Remains: Applications to Stratigraphic Analysis." In: C. A. Hastorf and V. S. Popper. (eds.) Current Paleoethnobotany. Chicago:Chicago University Press. pp. 86-96.

Asthana, S. 1976. History and Archaeology of India's Contacts with other Countries to 300 B.C. Delhi:B. R. Pub. Co.

Asthana, S. 1982. "Harappan Trade in Metals and Minerals: A Regional Approach." In: G. L. Possehl. (ed.) Harappan Civilization. :pp. 271-85. Delhi:American Institute of Indian Studies.

Bhandari, M. N. 1974. "Famine Foods in the Rajasthan Desert." Economic Botany. 28:73-81.

Bhandari, M. N. 1978. Flora of the Indian Desert.

Bharadwaj, O. P. 1961. "The Arid Zone of India and Pakistan." In: L. D. Stamp. (ed.) A History of Land Use in Arid Regions. Paris:UNESCO, Arid Zone Research. pp. 143-74.

Bharaucha, F. R. 1983. A Textbook of the Plant Geography of India. Bombay:Oxford University Press.

Blanford, W. J. 1876. "On the Physical Geography of the Graet Indian Deserts with Special Reference to the Former Existence of the Sea in the Indus Valley." Journal of the Asiatic Society of Bengal. 45(2):86-103.

Blanford, W. J. 1891. The Fauna of British India, including Ceylon and Burma. Mammalia. 1881-91. London:Taylor and Francis.

Bohrer, V. L. and K. R. Adams. 1977. Ethnobotanical Techniques and Approaches at Salmon Ruin, New Mexico. San Juan Valley Archaeological Project, Technical Series No. 2. Eastern New Mexico University Contribution in Anthropology, Vol 8, No. 1.

Bombay Presidency. 1880. Gazetteer of the Bombay Presidency, Cutch, Palanpur and Mahi Kantha. Volume V. Bombay.

Bombay Presidency. 1884a. Gazetteer of the Bombay Presidency: Kathiawar. Volume VII. Bombay.

Bombay Presidency. 1884b. Gazetteer of the Bombay Presidency: Sholapur. Volume XX. Bombay.

Bombay Presidency. 1886. Gazetteer of the Bombay Presidency: Botany. Volume XXV. Bombay:Government Central Press.

Boserup, E. 1965. The Conditions of Agricultural Growth: The Economics of Agrarian Change under Population Pressure. Chicago:Aldine.

Braidwood, R. J. and C. A. Reed. 1957. "The Achievement and Early Consequences of Food-Production: A Consideration of the Archeological and Natural-Historical Evidence." In: Cold Spring Harbor Symposia on Quantitative Biology. Volume 22. Long Island Biological Association. pp. 19-31.

Brandis, D. 1906. Indian Trees. New Delhi:BSMPS.

Briuer, F. 1976. "New Clues to Stone Tool Function: Plant and Animal Residues." American Antiquity. 41:178-84.

Brunken, J, J.M.J. de Wet and J. R. Harlan. 1977. "The Morphology and Domestication of Pearl Millet." Economic Botany. 31:163-74.

Bryson, R. A. and D. A. Baerris. 1967. "Possibilities of Major Climatic Modification and their Implications: Northwest India, a Case for Study." Bull. Amer. Meteor. Soc.48(3):136-42.

Burkill, I. H. 1953. "Chapter on the History of Botany in India - 1. From the Beginning to the Middle of Wallich's Service." Jour. Bombay Nat. Hist. Soc. 51(4):846-78.

Burkill, I. H. 1965. Chapters on the History of Botany in India. Delhi:Government of India Press.

Burnham, P. 1980. "Changing Agricultural and Pastoral Ecologies in the West African Savanna Region." In: D. R. Harris. (ed.) Human Ecology in Savanna Environments. New York:Academic Press. pp. 147-70.

Butzer, K. W. 1971. Environment and Archaeology: An Ecological Approach to Prehistory. Chicago:Aldine.

Bye, R. A. 1984. "Developing an Integrated Model for Contemporary and Archaeological Agricultural Subsistence Systems." In: P. Fish. (ed.) Prehistoric Agricultural Strategies in the Southwest. Arizona State University Papers, No. 33.

Bye, R. A. 1985. "Botanical Perspectives of Ethnobotany for the Greater Southwest." Economic Botany. 39(4):375-87.

Casal, J. M. 1961. "Rapport provisoire sur les fouilles executees a Amri (Pakistan) en 1959-1960." Arts Asiatiques. 8:11-26.

Casal, J. M. 1973. "Excavations at Pirak, West Pakistan." In: N. Hammond. (ed.) South Asian Archaeology. Park Ridge:Noyes Press. pp. 171-79.

Chalam, G. V. and J. Venkateswarlu. 1965. An Introduction to Agricultural Botany in India. Vol. 1. Bombay:ASIA.

Champion, H. G. 1935. "A Preliminary Survey of the Forest Types of India." Indian Forest Records. 1:1-204.

Champion, H. G. and S. K. Seth. 1968. A Revised Survey of Forest Types of India. Delhi:Government of India Press.

Chanchala. 1984. "Wild Plant Remains from the Archaeological Sites - a Palaeobotanical, Palaeoecological and Paleoethnobotanical Study." Ph.D. Dissertation. Birbal Sahni Institute of Palaeobotany, Lucknow.

Chandola, R. P. 1959. "Cytogenetics of Millets." Cytologia. 24(1):115-137.

Chitalwala, Y. M. 1982. "Harappan Settlements in the Kutch-Saurasthra Region: Patterns of Distribution and Routes of Communication." In: G. L. Possehl. (ed.) Harappan Civilization. Delhi:American Institute of Indian Studies. pp. 197-202.

Chowdhury, K. A. 1965. "Plant Remains from Pre- and Proto-Historic Sites and their Scientific Significance." Science and Culture. 31:177-78.

Chowdhury, K. A. and S. S. Ghosh. 1951. "Plants Remains from Harappa, 1946." Ancient India. 7:3-19.

Church, A. H. 1983. Food-Grains of India. New Delhi:AJAY Book Service.

Clark, J. G. D. 1954. Excavations at Star Carr: An Early Mesolithic Site at Seamer, near Scarborough, Yorkshire. London:Cambridge University Press.

Cohen, M. N. 1977 The Food Crisis in Prehistory. New Haven:Yale University Press.

Costantini, L. 1979a. "Notes on the Palaeoethnobotany of Protohistoric Swat." In: M. Taddei. (ed.) South Asian Archaeology 1977. :pp. 704-708. Naples:IsMEO.

Costantini, L. 1979b. "Plant Remains at Pirak, Pakistan." In: J-F Jarrige, M. Santoni and J. F. Enault. (eds.) Fouilles de Pirak. Publications de la Commision des Fouilles Archaeologiques. Fouilles du Pakistan 2:pp. 326-33. Paris:Diffusion de Boccand.

Costantini, L. 1981. "Palaeoethnobotany at Pirak: A Contribution to the 2nd Millennium B. C. Agriculture of the Sibi-Kacchi Plain, Pakistan." In: H. Hartel. (ed.) South Asian Archaeology, 1979. Berlin: Dietrich Reimer Verlag. pp. 271-77.

Costantini, L. 1984. "The Beginning of Agriculture in the Kachi Plain: The Evidence of Mehrgarh." In: B. Allchin. (ed.) South Asian Archaeology 1981. Cambridge:Cambridge Press. pp. 29-33.

Costantini, L. 1987. "Vegetal Remains." In: G. Stacul. (Prehistoric and Protohistoric Swat, Pakistan (c. 3000-1400 B.C.).) Appendix B. Rome:IsMEO. pp. 155-65.

Costantini, L. and L. C. Biasini. 1985. "Agriculture in Baluchistan between the 7th and the 3rd Millennium B.C." Newsletter of Baluchistan Studies. 2:16-37.

Crabtree, P. J. 1982. "A Summary of Current Approaches to Recovery of a Reliable Record of Ancient Plant Remains." MASCA Journal. 2(3):91-95.

Crabtree, P. 1985. "Faunal Remains." In: G. L. Possehl et al. Preliminary Report: Excavations at Rojdi: 1983-84. Man and Environment Vol. IX.

Dales, G. F. 1973. "Archaeological and Radiocarbon Chronologies for Prehistoric South Asia." In: N. Hammond. (ed.) South Asian Archaeology. :pp. 157-70. London:Gerald Duckworth and Co. Ltd.

Dales, G. F. 1979. "The Balakot Project: Summary of Four Years' Excavations in Pakistan." In: M. Taddei. (ed.) South Asian Archaeology 1977. :pp. 241-73. Naples: IsMEO.

Dales, G. F. 1964. "The Mythical Massacre of Mohenjo-daro." Expedition. 6(3):36-43.

Dales, G. F. 1965. "New Investigations at Mohenjo-daro." Archaeology. 18:145-50.

Dales, G. F. 1968. "Of Dice and Men." J. of the American Oriental Society. 88:14-23.

Dales, G. F. 1974. "Excavations at Balakot, Pakistan. 1973." Journal of Field Archaeology. 1(1-2):3-22.

Dales, G. F. and J. M. Kenoyer. 1987. "Preliminary Report on the University of California at Berkeley's Second Season at Harappa, Pakistan, January - April 1987." Unpublished Paper.

Dani, A. H. (ed.) 1981. Indus Civilization: New Perspectives. Islamabad:Quaid-i-Azam University.

De, D. N. 1974. "Pigeon Pea." In: Sir J. Hutchinson. (ed.) Evolutionary Studies in World Crops: Diversity and Change in the Indian Subcontinent. Cambridge:Cambridge University Press. pp. 79-87.

De Candolle, A. 1886. Origin of the Cultivated Plant. London:Kegan, Paul, Trench and Co.

De Wet, J.M.J. and J. R. Harlan. 1972. "The Origin and Domestication of Sorghum bicolor." Economic Botany. 25: 128-135.

Dennell, R. W. 1972. "The Interpretation of Plant Remains: Bulgaria." In: E. Higgs. (ed.) Papers in Economic Prehistory. Cambridge. pp. 149-50.

Dennell, R. W. 1974. "Botanical Evidence for Prehistoric Crop Processing Activities." Journal of Archaeological Science. 1:275-84.

Dennell, R. W. 1976. "The Economic Importance of Plant Resources Represented on Archaeological Sites." Journal of Archaeological Science. 3:229-47.

Dennell, R. W. 1983. "Dryland Agriculture and Soil Conservation: An Archaeological Study of Check-Dam Farming and Wadi Siltation." In: B. Spooner and H. S. Mann. (eds.) Desertification and Development: Dryland Ecology and Social Perspectives. New York:Academic Press.

Deo, S. B. 1970. Excavations at Takalghat and Khapa. Nagpur: Nagpur University.

Dhavalikar, M. K. and G. L. Possehl. 1974. "Subsistence Pattern of an Early Farming Community of Western India." Puratattva. 7:39-46.

Dikshit, K. N. 1977. "Distribution and Relationship of Proto-Historic Sites along the old River Channels of the Ghaggar System." In: D. P Agrawal and B. M. Pande. (eds.) Ecology and Archaeology of Western India. Delhi:Concept Pub. Co. pp. 61-66.

Dikshit, K. N. 1982. "Hulas and the Late Harappan Complex in Western Uttar Pradesh." In: G. L. Possehl. (ed.) Harappan Civilization. Delhi:American Institute of Indian Studies. pp. 339-52.

Dikshit, K. N. 1984. "The Harappan Levels at Hulas." Man and Environment. 8:99-102.

Dikshit, R. B. K. N. 1938. Prehistoric Civilization of the Indus Valley. Madras:University of Madras Press.

Dixit, A. S., S. S. Dixit and Vishnu-Mittre. 1987. "The Occurrence of Eleusine africana Kennedy O'Byrne in India and its Significance in the Origin of Eleusine coracana." Proc. Indian Acad. Sci. (Plant Sci.). 97(1): 1-10.

Dodia, R. 1988. "Climate of Kashmir during the Last 700,000 Years: The Baltal Pollen Profile." Proc. Indian natn. Sci. Acad. 54, A(3):481-89.

Dodia, R, H. P. Gupta, A. C.. Mandavia, C. Sharma and A. Vora. 1982. "Palynological Investigations on the Lower Karewas, Kashmir." Man and Environment. 6:21-26.

Dogget, H. 1970. Sorghum. London:Longmans, Green and Co.

During Caspers, E. L. 1972. "Harappan Trade in the Arabian Gulf in the Third Millennium B.C." Mesopotamia. 7(167-91)

Durrani, F. A. 1981. "Rehman Dheri and the Birth of Civilisation in Pakistan." Bulletin of the Institute of Archaeology. 18:191-207.

Ehrenfels, O. R. 1937. "Excavations at Chanhu daro." Nature. PP. 155ff.

Ehrenfels, O. R. 1939. "Excavations at Chanhu daro, Sind." Annual Report of the Archaeological Survey of India, Delhi. 1935-36:38-44.

Ellen, R. 1982. Environment, Subsistence and Systems. Cambridge:Cambridge University Press.

Euler, R.; G. Gummerman, T. Karlstrom, J. Dean, and R. Hevly. 1979. "Cultural Dynamics and Palaeoclimatic Correlation." Science. 205:1089-1101.

Fairservis, W. A. 1956. "Excavations in the Quetta Valley, West Pakistan." Anthro. Papers of the Amer. Mus. Nat. Hist. 45(2)

Fairservis, W. A. 1967. "The Origin, Character and Decline of an Early Civilization." Novitates. 2302

Fairservis, W. A. 1973. "Preliminary Report on Excavations at Allahdino (First Season, 1973)." Pakistan Archaeology. 9:95-102.

Fairservis, W. A. 1975. The Roots of Ancient India. [2nd ed] Chicago:University of Chicago Press.

Fairservis, W. A. 1988. "Cattle and the Harappan Chiefdoms of the Indus Valley." Expedition. 28(2):43-50.

Fentress, M. A. 1976. "Resource Access, Exchange Systems, and Regional Interation in the Indus Valley: An Investigation of Archaeological Variability at Harappa and Moenjodaro." Ph.D. Dissertation. Department of Oriental Studies, University of Pennsylvania.

Fentress, M. A. 1984. "The Indus 'Granaries': Illusion, Imagination, and Archaeological Reconstruction." In: K. A. R. Kennedy and G. L. Possehl. (eds.) Studies in the Archaeology and Paleoanthropology of South Asia. pp. 89-98. New Delhi:Oxford and IBH.

Field, B. 1977. "Development of a System for the Processing, Storage and Retrieval of Ethnobotanical Data." Occasional Papers, No. 32. London:Department of Geography, University College London.

Flam, L. 1981a. "The Paleogeography and Prehistoric Settlement Patterns in Sind, Pakistan (ca 4000 - 2000 B.C.)." Ph.D. Dissertation. Department of Oriental Studies, University of Pennsylvania.

Flam, L. 1981b. "Towards an Ecological Analysis of Prehistoric Settlement Patterns in Sind, Pakistan." Man and Environment. 5:52-58.

Flam, L. 1986. "Recent Explorations in Sind: Paleogeography, Regional Ecology, and Prehistoric Settlement Patterns (ca. 4000-2000 B.C.)." In: J. Jacobson. (ed.) Studies in the Archaeology of India and Pakistan. :pp. 65-90. New Delhi:Oxford and IBH Pub. Co.

Flannery, K. V. 1969. "Origins and Ecological Effects of Early Domestication in Iran and the Near East." In: P. Ucko and G. Dimbleby. (eds.) The Domestication and Exploitation of Plants and Animals. :pp. 73-97. Chicago: Aldine.

Flannery, K. V. 1973. "The Origins of Agriculture." Annual Review of Anthropology. 2:271-310.

Flannery, K. V. (ed.) 1986. Guila Naquitz: Archaic Foraging and Early Agriculture in Oaxaca, Mexico. New York: Academic Press.

Ford, R. I. 1978a. "Ethnobotany: Historical Diversity and Synthesis." In: R. I. Ford. (ed.) The Nature and Status of Ethnobotany. No.67. pp. 33-50. Ann Arbor:Museum of Anthropology.

Ford, R. I. (ed.) 1978b. The Nature and Status of Ethnobotany. University of Michigan Museum Anthropology papers, No. 60.

Ford, R. I. 1979. "Palaeoethnobotany in American Archaeology." In: M. Schiffer. (ed.) Advances in Archaeological Method and Theory. Volume 2. New York: Academic Press.

Ford, R. I. 1985a. "Anthropological Perspective of Ethnobotany in the Greater Southwest." Economic Botany. 39(4):400-15.

Ford, R. I. 1985b. "Patterns of Prehistoric Food Production in North America." In: R. I. Ford. (ed.) Prehistoric Food Production in North America. No. 75. pp. 341-364. Ann Arbor:Museum of Anthropology.

Ford, R. I. 1985c. "The Processes of Plant Food Production in Prehistoric North America." In: R. Ford. (ed.) Prehistoric Food Production in North America. No. 75. pp. 1-18. Ann Arbor:Museum of Anthropology.

Forde, C. D. 1934. Habitat, Economy and Society. London: Methuen.

Fox, R. 1969. "Professional Primitives." Man in India. 43: 139-52.

Fritts, H. 1966. "Growth-Rings of Trees: Their Correlation with Climate." Science. 154(973-79).

Gasser, R. E. 1985. "Archaeological Trash Mounds and Floor Features: Don't Believe Everything." Paper presented at the Society of Ethnobiology Conference 8th Annual Conference, Boston, 1985.

Gasser, R. E. and C. Adams. 1981. "Aspects of Deterioration of Plant Remains in Archaeological Sites: The Walapi Archaeological Project." Journal of Ethnobiology. 1(1): 182-92.

Gaussen, H, P. Legris, F. Blasco, V. M. Meher-Homji and J. P. Troy. 1968. "Notice de la feuille Kathiawar." Extrait des Travaux de la Section Scientifique et Technique de L'Institute Francais de Pondichery. Hors serie 9.

Ghosh, S. S. and K. R. Lal. 1963. "Plant Remains from Rangpur." Ancient India. 18-19:161-77.

Gifford, D. P. 1981. "Taphonomy and Paleoecology: A Critical Review of Archaeology's Sister Disciplines." In: M. Schiffer. (ed.) Advances in Archaeological Method and Theory. Volume 4. New York:Academic Press.

Government of Gujarat. 1961. Gujarat State Gazetteers: Broach District. Ahmedabad.

Government of Gujarat. 1962. Gujarat State Gazetteers: Surat District. Ahmedabad.

Government of Gujarat. 1965. Gujarat State Gazetteers: Rajkot District. Ahmedabad.

Government of Gujarat. 1969. Gujarat State Gazetteers: Bhavnagar District. Ahmedabad.

Government of Gujarat. 1970. Gujarat State Gazetteers: Jamnagar District. Ahmedabad.

Government of Gujarat. 1977. Gujarat State Gazetteers: Surendranagar District. Ahmedabad.

Government of Gujarat. 1979. Gujarat State Gazetteers: Baroda District. Ahmedabad.

Government of Gujarat. 1980. Gujarat State Gazetteers: Gandhinagar District. Ahmedabad.

Government of Gujarat. 1982. Statistical Atlas of Gujarat. Volume 1: Resource Profile. Gandhinagar:Bureau of Economics and Statistics.

Government of India. 1908. Imperial Gazetteer of India. Volume 15.[New Edition].

Government of India. 1948. The Wealth of India. Vol. I: A-B. pp.1-353. New Delhi:Council of Scientific and Industrial.

Government of India. 1950. The Wealth of India. Vol.II:C. New Delhi:Council of Scientific and Industrial Research.

Government of India. 1952. The Wealth of India. Vol. III: D-E. New Delhi:Council of Scientific and Industrial Resources.

Government of India. 1956. Wealth of India. Vol. IV: F-G. New Delhi:Council of Scientific and Industrial Research.

Government of India. 1959. Wealth of India. Vol. V: H-K. New Delhi:Council of Scientific and Industrial Research.

Government of India. 1962. The Wealth of India. Vol. VI: L-M. New Delhi:Council of Scientific and Industrial Research.

Government of India. 1964. National Atlas of India. Plate 62: Annual Temperature.

Government of India. 1965. The Gazetteer of India: Indian Union. Volume 1. Delhi.

Government of India. 1966. The Wealth of India. Vol. VII: N-Pe. New Delhi:Council of Scientific and Industrial Research.

Government of India. 1969. The Wealth of India. Vol. VIII: Ph-Re. New Delhi:Council of Scientific and Industrial Research.

Government of India. 1972. The Wealth of India. Vol. IX: Rh-So. New Delhi:Council of Scientific and Industrial Research.

Government of India. 1976a. The Wealth of India. Vol. X: Sp-W. New Delhi:Council of Scientific and Industrial Research.

Government of India. 1976b. The Wealth of India. Vol. XI: X-Z. New Delhi:Council of Scientific and Industrial Research.

Green, F. J. 1979. "Phosphatic Mineralization of Seeds from Archaeological Sites." Journal of Archaeological Science. 6:279-84.

Gupta, H. P. 1971a. "Pollen Analytical Investigations of Some Upper Pleistocence Samples from Tocklai, Cinnamara, Assam." The Palaeobotanist. 18(3):234-236.

Gupta, H. P. 1971b. "Studies of Indian Pollen Grains - IV. Boraginaceae." Geophytology. :127-34.

Gupta, H. P. 1978. "Holocene Palynology from Meander Lake in the Ganga Valley, District Pratapgarh, U. P." The Palaeobotanist. 25:109-19.

Gupta, H. P. and C. Sharma. 1982. "Quaternary Palynostratigraphy in India: A Critical Review." Spl. Publ. Palaeontol. Soc. India. 1:130-38.

Gupta, S. K. 1977a. "Holocene Silting in the Little Rann of Kutch." In: D. P. Agrawal and B. M. Pande. (eds.) Ecology and Archaeology of Western India. pp. 201-5. Delhi:Concept Publishers.

Gupta, S. K. 1977b. "Quaternary Sea-Level Changes on the Saurashtra Coast." In: D. P. Agrawal and B. M. Pande. (eds.) Ecology and Archaeology of Western India. pp. 181-93. Delhi:Concept Publishers.

Halbirt, C. D. 1978. "Prehistoric Site Development and Related Pollen Influx." Unpublished Paper. Northern Arizona University.

Harlan, J. R. 1970. "Evolution of Cultivated Plants." In: Frankels and Bennet. (ed.) Genetic Resources in Plants: Their Exploration and Conservation. Philadelphia:I. A. Davis Co.

Harlan, J. R. 1976. "Plant and Animal Distribution in Relation to Domestication." Phil. Trans. R. Soc. Lond. B. 275:13-26.

Harlan, J. R. 1977. "The Origins of Cereal Agriculture in the Old World." In: C. A. Reed. (ed.) Origins of Agriculture. pp. 357-383.

Harlan, J. R. and J.M.J. de Wet. 1973. "On the Quality of Evidence for Origin and Dispersal of Cultivated Plants." Current Anthropology. 14:57-62.

Harris, D. R. 1969. "Agricultural Systems, Ecosystems and the Origins of Agriculture." In: P. J. Ucko and G. W. Dimbleby. (eds.) The Domestication and Exploitation of Plants and Animals. pp. 3-15. Chicago:Aldine.

Harris, D. R. 1977. "Alternate Pathways Toward Agriculture." In: C. A. Reed. (ed.) Origins of Agriculture. pp. 179-233. Paris:Mouton.

Harris, D. R. (ed.) 1980. Human Ecology in Savanna Environments. New York:Academic Press.

Harris, D. R. 1987. "The Impact on Archaeology of Radiocarbon Dating by Accelerator Mass Spectrometry." Phil. Trans. R. Soc. Lond. B. 323:23-43.

Harshberger, J. W. 1896. "The Purpose of Ethnobotany." American Antiquarian. 17:73-81.

Hastorf, C. A. 1989. "The Use of Paleoethnobotanical Data in Prehistoric Studies of Crop Production, Processing, and Consumption." In: C. A. Hastorf and V. S. Popper. (eds.) Current Paleoethnobotany. pp. 119-144. Chicago: University of Chicago Press.

Hegde, K. 1977. "Late Quaternary Environments in Gujarat and Rajasthan." In: D. P. Agrawal, B. M.. Pande. (eds.) Ecology and Archaeology of Western India. pp. 169-80. Delhi:Concept Pub. Co.

Herman, C. F. 1989. "Rojdi Material Culture: The Sorath Harappan Ceramics." In: G. L. Possehl and M. H. Raval. (eds.) Harappan Civilization and Rojdi. pp. 53-156. New Delhi:Oxford and IBH Publ. Co.

Hevly, R. H. 1981. "Pollen Production, Transport and Preservation: Potentials and Limitations in Archaeological Palynology." Journal of Ethnobiology. 1(1):39-54.

Higgs, E. S. (ed.) 1975. Paleoeconomy. Cambridge:Cambridge University Press.

Higgs, E. S. and M. R. Jarman. 1972. "The Origins of Agriculture and Plant Husbandry." In: E. S. Higgs. (ed.) Papers in Economic Prehistory. pp. 3-13. London: Cambridge University Press.

Hill, J. and R. H. Hevly. 1968. "Pollen at Broken K Pueblo: Some New Interpretations." American Antiquity. 33:200-10.

Hillman, G. 1975. "The Plant Remains from Tell Abu Hureyra: A Preliminary Report." Proc. Preh. Soc. 41:70-73.

Hillman, G. 1981. "Reconstructing Crop Husbandry Practices from Charred Remains of Crops." In: R. Mercer. (ed.) Farming Practice in British Prehistory. pp. 123-162. Edinburgh:Edinburgh University Press.

Hillman, G. 1983. "Interpretation of Archaeological Plant Remains: The Application of Ethnographic Models from Turkey." In: Van Zeist, W. and W. A. Casparie. (eds.) Plants and Ancient Man: Studies in Palaeoethnobotany. Proceedings of the Sixth Symposium of the International Work Group for Palaeoethnobotany/Groningen/30 May - 3 June 1983. Rotterdam:A. A. Balkema.

Hillman, G. 1984. "Traditional Husbandry and Processing of Archaic Cereals in Recent Times: The Operations, Products and Equipment which might feature in Sumerian Texts. Part I: The Glume Wheats." In: Bulletin on Sumerian Agriculture. Volume One:pp. 114-52. Cambridge.

Hillman, G. 1985. "Traditional Husbandry and Processing of Archaic Cereals in Recent Times: The Operations, Products and Equipment that might feature in Sumerian Texts. Part II: The Free-Threshing Cereals." In: Bulletin on Sumerian Agriculture. Volume Two. Cambridge.

Hillman, G, G. V. Robins, D. Oduwole, K. D. Sales, and D. A. C. McNeil. 1983. "Determination of Thermal Histories of Archaeological Cereal Grains with Electron Spin Resonance Spectroscopy." Science. 222:1235-1236.

Hilu, K. W., J. M. de Wet and J. R. Harlan. 1979. "Archaeobotanical Studies of Eleusine coracana ssp. coracana (Finger millet)." American Journal of Botany. 66(3):330-333.

Ho, P. 1975. The Cradle of East. Chicago:University of Chicago Press.

Ho, P. 1977. "The Indigenous Origins of Chinese Agriculture." In: C. A. Reed. (ed.) Origins of Agriculture. pp. 413-473.

Hodder, I. R. 1983. The Present Past. New York:Pica Press.

Hodder, I. R. and C. Orton. 1976. Spatial Analysis in Archaeology. New York:Cambridge University Press.

Hooker, J. D. 1872. The Flora of British India (Volumes I-VII). London:William Clowes and Sons.

Hutchinson, J. B. 1974. "Crop Plant Evolution in the Indian Subcontinent." In: J. B. Hutchinson. (ed.) Evolutionary Studies in World Crops. pp. 151-60.

Hutchinson, J. B. 1976. "India: Local and Introduced Crops." Phil. Trans. R. Soc. Lond. B. 275:129-141.

Iltis, H. 1983. "From Teosinte to Maize: The Catastrophic Sexual Transmutation." Science. 4626:886-94.

India Meteorological Department. 1970. Monthly and Annual Rainfall and Number of Rainy Days: Period 1901-1950. Part IV. Anasik:Government of India Press.

Indian Archaeology: A Review 1953-54. 1954. Government of India.

Indian Archaeology: A Review 1954-55. 1955. Government of India.

Indian Archaeology: A Review 1955-56. 1956. Government of India.

Indian Archaeology: A Review 1956-57. 1957. Government of India.

Indian Archaeology: A Review 1957-58. 1958. Government of India.

Indian Archaeology: A Review 1958-59. 1959. Government of India.

Indian Archaeology: A Review 1959-60. 1960. Government of India.

Indian Archaeology: A Review 1960-61. 1961. Government of India.

Indian Archaeology: A Review 1961-62. 1964. Government of India.

Indian Archaeology: A Review 1962-63. 1965. Government of India.

Indian Archaeology: A Review 1963-64. 1967. Government of India.

Indian Archaeology: A Review 1967-68. 1968. Government of India.

Indian Archaeology: A Review 1964-65. 1969. Government of India.

Indian Archaeology: A Review 1970-71. 1971. Government of India.

Indian Archaeology: A Review 1968-69. 1971. Government of India.

Indian Archaeology: A Review 1971-72. 1972. Government of India.

Indian Archaeology: A Review 1972-73. 1973. Government of India.

Indian Archaeology: A Review 1969-70. 1973. Government of India.

Indian Archaeology: A Review 1965-66. 1973. Government of India.

Indian Archaeology: A Review 1973-74. 1974. Government of India.

Indian Archaeology: A Review 1966-67. 1974. Government of India.

Indian Archaeology: A Review 1974-75. 1975. Government of India.

Indian Archaeology: A Review 1975-76. 1976. Government of India.

Indian Archaeology: A Review 1976-77. 1977. Government of India.

Indian Archaeology: A Review 1977-78. 1978. Government of India.

Indian Archaeology: A Review 1978-79. 1979. Government of India.

Indian Archaeology: A Review 1979-80. 1980. Government of India.

Indian Archaeology: A Review 1980-81. 1981. Government of India.

Indian Archaeology: A Review 1981-82. 1982. Government of India.

Indian Archaeology: A Review 1982-83. 1983. Government of India.

Indian Archaeology: A Review 1983-84. 1984. Government of India.

Indian Archaeology: A Review 1984-85. 1985. Government of India.

Jacobson, J. 1979. "Recent Developments in South Asian Prehistory and Protohistory." Annual Reviews in Anthropology. 8:467-502.

Jacobson, J. 1986. "The Harappan Civilization: An Early State." In: J. Jacobson. (ed.) Studies in the Archaeology of India and Pakistan. pp. 137 - 174. New Delhi:Oxford and IBH.

Jafri, S. M.. H. 1966. The Flora of Karachi. Karachi:Karachi Book Corp.

Jain, S. K. 1981. Glimpses of Indian Ethnobotany. New Delhi: Oxford and IBH Publishing Co.

Jarman, M. R., C. Vita-Finzi, and E. S. Higgs. 1972. "Site Catchment Analysis in Archaeology." In: P. J. Ucko, R. Tringham and G. W. Dimbleby. (eds.) Man, Settlement, and Urbanism. London:Duckworth.

Jarrige, J-F. 1979. "Excavations at Mehrgarh - Pakistan." In: J. E. van Lohuizen-de Leeuw. (ed.) South Asian Archaeology 1975. pp. 76-87. Leiden:E. J. Brill.

Jarrige, J-F. 1984a. "Chronology of the Earlier Periods of the Greater Indus as Seen from Mehrgarh, Pakistan." In: B. Allchin. (ed.) South Asian Archaeology 1981. pp. 21-8. Cambridge:Cambridge University Press.

Jarrige, J-F. 1984b. "Towns and Villages of Hill and Plain." In: B. B. Lal and S. P. Gupta. (eds.) Frontiers of the Indus Civilization. :pp. 289-300. Delhi:Books and Books.

Jarrige, J-F. 1985. "Continuity and Change in the North Kachi Plain (Baluchistan, Pakistan) at the Beginning of the Second Millennium B.C." In: J. Schotsmans and M. Taddei. (eds.) South Asian Archaeology 1983. :pp. 35-68. Naples:IsMEO.

Jarrige, J-F. 1986. Excavations at Mehrgarh-Naushero: The Twelfth Season: 1985-86. Paris:Musee Guimet, French Archaeological Mission to Pakistan.

Jarrige, J-F and M. Lechevallier. 1979. "Excavations at Mehrgarh, Baluchistan: Their Signficance in the Prehistorical Context of the Indo-Pakistan Borderlands." In: M. Taddei. (ed.) South Asian Archaeology 1977. pp. 463-536. Naples:IsMEO.

Jarrige, J-F and R. H. Meadow. 1980. "The Antecedents of Civilization in the Indus Valley." Scientific American. 243(2):122-33.

Jarrige, J-F and M. Santoni. 1979. Fouilles de Pirak. Publications de la Commission des Fouilles Archaeologiques. Fouilles du Pakistan 2:

Jochim, M. 1976. Hunter-Gatherer Subsistence and Settlement: A Predictive Model. New York:Academic Press.

Johannessen, S. 1989. "Plant Remains and Culture Change: Are Paleoethnobotanical Data Better Than We Whink?" In: C. A. Hastorf and V. S. Popper. (eds.) Current Paleoethnobotany. pp. 145-166. Chicago:University of Chicago Press.

Joshi, J. P. 1972a. "Exploration in Kutch and Excavation at Sur Kotada and New Light on Harappan Migration." Journal of the Oriental Institute, Baroda. 22(1-2):98-144.

Joshi, J. P. 1972b. "Exploration in Kutch and Excavations at Surkotada and New Light on Harappan Migration." Journal of the Oriental Institute, University of Baroda. 22(1-2):98-144.

Joshi, J. P. 1972c. "Fresh Light on the Archaeology of Kutch." In: S. B. Deo. (ed.) Archaeological Congress and Seminar Papers. Nagpur:Nagpur University.

Joshi, J. P. 1976. "Transformation of Harappa Culture in Kutch: Examination of Evidence from Surkotada." In: U. V. Singh. (ed.) Archaeological Congress and Seminar: 1972. Kurukshetra:Kurukshetra University.

Joshi, J. P. 1979. "The Nature of Settlement at Surkotada." In: D. P. Agrawal and D. K. Chakrabarti. (eds.) Essays in Indian Protohistory. pp. 59-64. Delhi:B. R. Publishing.

Joshi, J. P. and M. Bala. 1982. "Manda: A Harappan Site in Jammu and Kashmir." In: G. L. Possehl. (ed.) Harappan Civilization. :pp. 185-96. Delhi:American Institute of Indian Studies.

Kadane, J. B. 1989. "Possible Statistical Contributions to Paleoethnobotany." In: C. A. Hastorf and V. S. Popper. (eds.) Current Paleoethnobotany. pp. 206-214. Chicago: University of Chicago Press.

Kajale, M. D. 1974. "Ancient Grains from India." Bulletin of the Deccan College Research Institute. 34(1-4):55-74.

Kajale, M. D. 1988a. "Ancient Plant Economy at Chalcolithic Tuljapur Garhi, District Amraoti, Maharashtra." Current Science. 57(7):377-79.

Kajale, M. D. 1988b. "Plant Economy." In: M. K. Dhavalikar, H. D.. Sankalia and Z. D. Ansari. (eds.) Excavations at Inamgaon. Volume One: Part ii. pp. 727-821. Pune:Deccan College Postgraduate and Research Institute.

Kajale, M. D. 1989. "Archaeobotanical Investigation on Megalithic Bhagimohari, and its Significance for Ancient Indian Agricultural System." Man and Environment. 13:87-100.

Kane, V. S. 1989. "Animal Remains from Rojdi." In: G. L. Possehl and M. H. Raval. (eds.) Harappan Civilization and Rojdi. pp. 182-84. New Delhi:Oxford and IBH Publ. Co.

Kazmi, S. M. A. 1970. Bibliography on the Botany of West Pakistan and Kashmir and Adjacent Regions. Florida:Field Research Projects.

Keepax, C. 1977. "Contamination of Archaeological Deposits by Seeds of Modern Origin with Particular Reference to the Use of Flotation Machines." Journal of Archaeological Science. 4:221-29.

Kennedy, K. A. R. 1982. "Skulls, Aryans, and Flowing Drains: The Interface of Archaeology and Skeletal Biology in the Study of the Harappan Civilization." In: G. L. Possehl. (ed.) Harappan Civilization. pp. 289-96. Delhi:American Institute of Indian Studies.

Kent, S. 1984. Analyzing Activity Areas. Albuquerque: University of New Mexico.

Khan, M. 1987. "Plant Husbandry of Archaeological Sites in Kashmir." Ph.D. Dissertation. University of Kashmir.

Kidder, A. V. and S. Guernsey. 1919. "Archaeological Explorations in Northeastern Arizona." Bureau of American Ethnology Bulletin. 65

Kirtikar, K. R. and B. D. Basu. 1918. Indian Medicinal Plants. Delhi:Taj Offset Press.

Kramer, C. (ed.) 1979. Ethnoarchaeology: Implications of Ethnography for Archaeology. New York:Columbia University Press.

Kumar, L. S., A. Aggarwala, H. R. Arakeri, M. G. Karmath and E. Moore. 1963. Agriculture in India. Vol II CropsBombay:ASIA Publ.

Kurup, P. N. V. 1979. Handbook of Medicinal Plants. New Delhi:CCRAS.

Lal, B. B. 1970. "Perhaps the Earliest Ploughed Field so far Excavated Anywhere in the World." Puratattva. 4:1-3.

Lal, B. B. 1979. "Kalibangan and the Indus Civilization." In: D. P. Agrawal and D. K. Chakrabarti. (eds.) Essays in Indian Protohistory. pp. 65-97. Delhi:B. R. Publishing.

Lal, B. B. and S. P. Gupta. (eds.) 1984. Frontiers of the Indus Civilization. Delhi:Books and Books.

Lambrick, H. T. 1964. Sind: A General Introduction. Hyderabad:Sindhi Adabi Board.

Learmonth, A. T. A. 1964. "The Vegetation of the Indian Subcontinent." Australian National University School of General Studies, Dept of Geography, Occasional Paper 1.

Legris, P. 1963. La Vegetation de L'Inde: Ecologie et Flore. Pondichery, Travaux de la Section Scientifique et Technique. Tome 6.

Leshnik, L. S. 1968. "The Harappan 'Port' at Lothal: Another View." American Anthropologist. 70:911-22.

Leshnik, L. S. 1973. "Land Use and Ecological Factors in Prehistoric North-West India." In: N. Hammond. (ed.) South Asian Archaeology. pp. 67-84. London:Gerald Duckworth and Co. Ltd.

Lewis, R. 1981. "Use of Opal Phytolithics in Paleoenvironmental Reconstruction." Journal of Ethnobiology. 1(1):175-81.

Mackay, E. J. H. 1943. Chanhu-daro Excavations 1935-36. Boston:Museum of Fine Arts, American Oriental Series.

MacNeish, R. S. 1961. "Preliminary Archaeological Investigation in the Sierra de Tamaulipas, Mexico." Transactions of the American Philosophical Society. 48(6):1-210.

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Mann, H. H. 1955. Rainfall and Famine: A Study of Rainfall in the Bombay Deccan, 1865-1938. Bombay:Indian Society of Agricultural Economics.

Marshall, Sir J. 1931. Mohenjo Daro and the Indus Civilization. London:A. Probsthain.

Matthews, M, A. Hand and B. F. Benz. 1983. "Developing an Ecological-Behavioral Model for the Interpretation of Pioneer Plant Remains in Archaeological Deposits." Paper Presented at the Society for American Archaeology 48th Annual Meeting, Pittsburgh. April 1983.

McKean, M. B. 1983. "The Palynology of Balakot, a Pre-Harappan and Harappan Age Site In Las Bela, Pakistan." Ph.D. Dissertation. University Microfilms:Southern Methodist University.

Meadow, R. H. 1979. "Prehistoric Subsistence at Balakot: Initial Consideration of the Faunal Remains." In: M. Taddei. (ed.) South Asian Archaeology 1977. pp. 275-315. Naples:IsMEO.

Meadow, R. H. 1981. "Early Animal Domestication in South Asia: A First Report of the Faunal Remains from Mehrgarh, Pakistan." In: H. Hartel. (ed.) South Asian Archaeology 1979. pp. 143-79. Berlin:Dietrich Reimer Verlag.

Meadow, R. H. 1984. "Animal Domestication in the Middle East: A View from the Eastern Margin." In: J. Clutton-Brock and C. Grigson. (eds.) Animals and Archaeology: 3.Early Herders and their Flocks. pp. 309-37. British Archaeological Reports International Series 202:

Meadow, R. H. 1988. "The Domestication and Exploitation of Plants and Animals in the Greater Indus Valley, 7th-2nd Millennium B.C." Manuscript

Meher-Homji, V. M. 1977. "History of the Dry Deciduous Forests of Western and Central india." In: D. P. Agrawal, and B.. M. Pande. (eds.) Ecology and Archaeology of Western India. pp. 109-26. Delhi:Concept Pub. Co.

Meher-Homji, V. M. 1980. "The Thar Desert: Its Climatic History." Man and Environment. 4:1-7.

Meher-Homji, V. M. 1989. "History of Vegetation of Peninsular India." Man and Environment. 13:1-10.

Mehra, K. L. 1963. "Considerations of the African Origin of Eleusine coracana (L.) Gaertn." Current Science. 7:300-301.

Mehta, R. N. 1982. "Some Rural Harappan Settlements in Gujarat." In: G. L. Possehl. (ed.) Harappan Civilization. pp. 167-74. Delhi:American Institute of Indian Studies.

Mehta, R. N. 1984. "Valabhi: A Station of Harappan Cattle Breeders." In: B. B. Lal and S. P. Gupta. (eds.) Frontiers of the Indus Civilization. pp. 227-30. Delhi:Books and Books.

Michael, H. N. 1982. "Table of Calibrated Ranges (67% Confidence) of Radiocarbon Dates." Unpublished. April 2, 1982.

Miksicek, C. H. 1983. "Archaeobotanical Aspects of Las Fosas: A Statistical Approach to Prehistoric Plant Remains." In: L. S. Teague and P. L. Crown. (eds.) Hohokam Archaeology along the Salt-Gila Aqueduct. Volume VI, parts V and VI. pp. 671-700. Arizona State Museum Archaeology Series No. 150.

Miller, D. 1985a. Artefacts as Categories: A Study of Ceramic variability in Central India. Cambridge: Cambridge University Press.

Miller, D. 1985b. "Ideology and the Harappan Civilization." Journal of Anthropological Archaeology. 4:34-71.

Miller, N. F. 1982. "Economy and Environment of Malyan, A Third Millennium b.c. Urban Center in Southern Iran (Volumes I and II)." Ph.D. dissertation. University Microfilms:University of Michigan.

Miller, N. F. 1984. "The Use of Dung as Fuel: An Ethnographic Example and an Archaeological Application." Paleorient. 10/2:71-79.

Miller, N. F. 1988. "What Mean These Seeds: A Comparative Approach to Archaeological Seeds Analysis." Paper Presented at the Society for Historical Archaeology Annual Meeting, Reno, Nevada.

Miller, N. F. 1989. "Ratios in Paleoethnobotanical Analysis." In: C. A. Hastorf and V. S. Popper. (eds.) Current Paleoethnobotany. pp. 72-85. Chicago:Chicago University Press.

Miller, N. F. and T. L. Smart. 1984. "Intentional Burning of Dung as Fuel: A Mechanism for the Incorporation of Charred Seeds into the Archaeological Record." Journal of Ethnobiology. 4(1):15-28.

Mills, W. 1901. "Plant Remains from the Baun Village Site." Ohio Naturalist. 1(5):70-1.

Minnis, P. E. 1978. "Paleoethnobotanical Indications of Prehistoric Environmental Disturbance: a Case Study." In: R. Ford. (ed.) The Nature and Status of Ethnobotany. No. 67:pp. 374-366. Ann Arbor:Museum of Anthropology.

Minnis, P. E. 1981. "Seeds in Archaeological Sites: Sources and Some Interpretative Problems." American Antiquity. 16(1):143-152.

Minnis, P. E. 1985a. "Domesticating People and Plants in the Greater Southwest." In: R. Ford. (ed.) Prehistoric Food Production in North America. No. 75. pp. 309-340. Ann Arbor:Museum of Anthropology.

Minnis, P. E. 1985b. Social Adaptation to Food Stress: A Prehistoric Southwestern Example. Chicago:University of Chicago Press.

Minnis, P. E. 1986. "Macroplant Remains." In: B. A. Nelson and S. A. LeBlanc. (eds.) Short-Term Sedentism in the American Southwest: The Mimbres Valley Salado. pp. 205-18. Albuquerque:Maxwell Museum of Anthropology and University of New Mexico Press.

Minnis, P. E. and R. I. Ford. 1977. "Analysis of Plant Remains from Chimney Rock Mesa." In: F. Eddy. (ed.) Archaeological Investigation at Chimney Rock Mesa, 1970-72. Memoirs of the Colorado Archaeological Society, 1: pp. 81-91.

Misra, V. N. 1965. "Review of Ancient India Nos. 18 and 19." The Eastern Anthropologist. 18(1):44-52.

Momin, K. N. 1984. "Village Harappans in Kheda District of Gujarat." In: B. B. Lal and S. P Gupta. (eds.) Frontiers of the Indus Civilization. pp. 231-4. Delhi:Books and Books.

Morgan, L. H. 1877. Ancient Society. New York:Holt.

Mughal, M. R. 1972. "A Summary of Excavations and Explorations in Pakistan." Pakistan Archaeology. 8:113-58.

Mughal, M. R. 1975. "Present State of Research on the Indus Valley Civilization." In: Ahmed Nabi Khan. (ed.) International Symposium on Mohenjodaro. pp. 37-57.

Mughal, M. R. 1970. "The Early Harappan Period in the Greater Indus Valley and Northern Baluchistan." Ph.D. Dissertation. University of Pennsylvania.

Mughal, M. R. 1980. "Archaeological Surveys in Bahawalpur." Unpublished manuscript. Karachi, Department of Archaeology and Museums:

Mughal, M. R. 1982. "Recent Archaeological Research in the Cholistan Desert." In: G. L. Possehl. (ed.) Harappan Civilization. pp. 85-96. Delhi:American Institute of Indian Studies.

Mughal, M. R. 1988. "Genesis of the Indus Valley Civilization." Lahore Museum Bulletin. 1(1):45-54. Karachi:National book Foundation.

Musil, A. T. 1963. Identification of Crop and Weed Seeds. Washington D.C.:U.S. Dept of Agriculture Handbook 219.

Nanavati, J. M., R. N. Mehta, and S. N. Chowdhary. 1971. Somnath - 1956. Monograph 1. Baroda:Department of Archaeology, Gujarat State and Department of Archaeology and Ancient History, M. S. University of Baroda.

Narain, A. 1974. "Rape and Mustard." In: Sir J. Hutchinson. (ed.) Evolutionary Studies in World Crops: Diversity and Change in the Indian Subcontinent. pp. 67-70. Cambridge:Cambridge University Press.

Nayar, M. P. 1985. Meaning of Indian Flowering Plant Names. New Delhi:B.S.M.P.L.

Pande, B. M. 1977. "Archaeological Remains on the Ancient Saraswati." In: D. P. Agrawal and B. M. Pande. (eds.) Ecology and Archaeology of Western India. pp. 55-60. Delhi:Concept Pub. Co.

Patel, G. 1977. Gujarat's Agriculture. Ahmedabad:Overseas Book Traders.

Pearsall, D. M. 1983. "Evaluating the Stability of Subsistence Strategies by Use of Paleoethnobotanical Data." Journal of Ethnobiology. 3(2):121-37.

Pearsall, D. M. 1989a. "Interpreting the Meaning of Macroremain Abundance: The Impact of Source and Context." In: C. A. Hastorf and V. S. Popper. (eds.) Current Paleoethnobotany. pp. 97-118. Chicago: University of Chicago Press.

Pearsall, D. M. 1989b. Paleoethnobotany. New York:Academic Press.

Pickersill, B. 1972. "Cultivated Plants as Evidence for Cultural Contact." American Antiquity. 37(97-104)

Piggott, S. 1950. Prehistoric India to 1000 B.C. Baltimore: Penguin.

Piggott, S. 1962. Prehistoric India. [2nd Edition] London: Cassell.

Popper, V. S. 1989. "Selecting Quantitative Measurements in Paleoethnobotany." In: C. A. Hastorf and V. S. Popper. (eds.) Current Paleoethnobotany. pp. 53-71. Chicago: Chicago University Press.

Possehl, G. L. 1974. "Variation and Change in the Indus Civilization." Ph.D. Dissertation. Department of Anthropology, University of Chicago.

Possehl, G. L. 1975. "The Chronology of Gabarbands and Palas in Western South Asia." Expedition. 17(2):33-37.

Possehl, G. L. 1976. "Lothal: A Gateway Settlement of the Harappan Civilization." In: K. A. R. Kennedy and G L Possehl. (eds.) Ecological Backgrounds of South Asian Prehistory. Ithaca:Cornell University South Asia Program.

Possehl, G. L. 1979. "Pastoral Nomadism in the Indus Civilization: An Hypothesis." In: M. Taddei. (ed.) South Asian Archaeology 1977. pp. 537-551. Naples:IsMEO.

Possehl, G. L. 1980. Indus Civilization in Saurashtra. Delhi:B. R. Publishing.

Possehl, G. L. (ed.) 1982. Harappan Civilization. Delhi: American Institute of American Studies.

Possehl, G. L. 1984. "Archaeological Terminology and the Harappan Civilization." In: B. B. Lal and S. P. Gupta. (eds.) Frontiers of the Indus Civilization. :pp. 27-36. Delhi:Books and Books.

Possehl, G. L. 1986. "African Millets in South Asian Prehistory." In: J. Jacobson. (ed.) Studies in the Archaeology of India and Pakistan. :pp. 237-256. New Delhi:Oxford and IBH.

Possehl, G. L. 1988. "Indian Archaeology, A Review: Guide to Excavated Sites 1953-54 through 1984-85." Puratattva. 1987-88 18:113-71.

Possehl, G. L. 1989. "Regionalism and the Harappan Civilization." Paper Presented at the Society for American Archaeology 54th Annual Meeting, Atlanta, Georgia. April 6, 1989.

Possehl, G. L., Y. M. Chitalwala, P. Rissman and G. Wagner. 1983. "Excavations at Rojdi: 1982-83." Puratattva. 1981-8313-14(13-14):155-63.

Possehl, G. L., Y. M. Chitalwala, P. C. Rissman, G. E. Wagner, P. J. Crabtree, and J. Longenecker. 1985. "Preliminary Report on the Second Season of Excavations at Rojdi: 1983-84." Man and Environment. IX:80-100.

Possehl, G. L. and C. F. Herman. In Press. "The Sorath Harappan: A New Regional Manifestation of the Indus Urban Phase." In: M. Taddei. (ed.) South Asian Archaeology 1987. Naples:IsMEO.

Possehl, G. L. and K. A. R. Kennedy. 1979. "Hunter-Gatherer/ Agriculturalist Exchange in Prehistory: An Indian Example." Current Anthropology. 20:592-3.

Possehl, G. L. and M. H. Raval. 1989. Rojdi and the Indus Civilization.

Possehl, G. L. and P. Rissman. In Press. "The Chronology of Prehistoric India." In: R. W. Ehrich. (ed.) Chronologies in Old World Archaeology. [2nd Edition]

Puri, G. S. 1960. Indian Forest Ecology. Delhi:Oxford Book Co.

Raikes, R. L. 1965a. "The Ancient Garbarbands of Baluchistan." East and West. 15:26-35.

Raikes, R. L. 1965b. "Physical Environment and Human Settlement in Prehistoric Times in the Near and Middle East: A Hydrological Approach." East and West. 15:179-93.

Raikes, R. L. 1968a. "Archaeological Explorations in Southern Jhalawan, and Las Bela (Pakistan)." Origini. 2:103-71.

Raikes, R. L. 1968b. "Kalibangan: Death from Natural Causes." Antiquity. 42:286-91.

Raikes, R. L. and R. H. Dyson Jr. 1961. "The Prehistoric Climate of Baluchistan and the Indus Valley." American Anthropologist. 63:265-81.

Rajaguru, S. N. 1973. "Late Pleistocene Climatic Changes in Western India." In: D. P. Agrawal and A. Ghosh. (eds.) Radiocarbon and Indian Archaeology. pp. 80-87. Tata Institute of Fundamental Research.

Ramaswamy, C. 1968. "Monsoon over the Indus Valley during the Harappan Period." Nature. 217:628-29.

Randhawa, M. S. 1980. A History of Agriculture in India. New Delhi:Indian Council of Agricultural Research.

Rao, K. E., J. M. J. de Wet, B. E. Brink and M. H. Mengesha. 1987. "Infraspecific Variation and Systematics of Cultivated Setaria italica, Foxtail Millet." Economic Botany. 41(1):108-116.

Rao, S. R. 1963. "Excavations at Rangpur and Other Explorations in Gujarat." Ancient India. 18-19:5-207.

Rao, S. R. 1973. Lothal and the Indus Civilization. New York:Asia Publishing House.

Rao, S. R. 1979. Lothal: A Harappan Port Town (1955-62). Delhi:Memoirs of the Archaeological Survey of India 78.

Ratnagar, S. 1982. Encounters: The Westerly Trade of the Harappan Civilization. Oxford:Oxford University Press.

Ratnagar, S. 1986. "An Aspect of Harappan Agricultural Production." Studies in History. 2(2):137-53.

Reed, C. A. (ed.) 1977. Origins of Agriculture. Paris: Mouton.

Renfrew, J. M. 1969. "The Archaeological Evidence for the Domestication of Plants: Methods and Problems." In: P. J. Ucko and G. W. Dimbleby. (eds.) The Domestication and Exploitation of Plants and Animals. pp. 149-69. Chicago:Aldine.

Renfrew, J. M. 1973. Palaeoethnobotany. New York:Columbia University Press.

Rindos, D. 1984. The Origin of Agriculture: An Evolutionary Perspective. Orlando:Academic Press.

Rissman, P. C. 1985. "Migratory Pastoralism in Western India in the Second Millennium B.C.: The Evidence from Oriyo Timbo." Ph.D. Dissertation. Department of Anthropology, University of Pennsylvania.

Sali, S. A. 1982. "The Harappans of Daimabad." In: G. L. Possehl. (ed.) The Harappan Civilization: A Contemporary Perspective. pp. 175-84. New Delhi:Oxford and IBH Publ. Co.

Sali, S. A. 1986. Daimabad, 1976-79. Delhi:Memoirs of the Archaeology Survey of India, No 83.

Sankalia, H. D. 1974. Prehistory and Protohistory of India and Pakistan. Pune: Deccan College.

Sankalia, H. D. 1987. Prehistoric and Historic Archaeology of Gujarat. New Delhi:Munshiram Manoharlal.

Sankalia, H. D., and Ansari, Z D, and M. K. Dhavalikar. 1975. "An Early Farmers' Village in Central India." Expedition. 17(2):2-11.

Sankalia, H. D., and Deo, S B, and Z. D. Ansari. 1969. Excavations at Ahar. Pune:Deccan College.

Sankalia, H. D, and Deo, S B, and Z. D. Ansari. 1971. Chalcolithic Navdatoli. Pune-Baroda:Deccan College and M. S. University Publication 2.

Santhanam, V. and J. B. Hutchinson. 1974. "Cotton." In: Sir J. Hutchinson. (ed.) Evolutionary Studies in World Crops. pp. 89-100. Cambridge:Cambridge University Press.

Saraswat, K. S. 1981. "Plant Economy in Ancient Sringaverapura Phase - I (c. 1050-1000 B.C.)." Puratattva. 1980-81 12:11-87.

Sarma, J. K. 1972. "South-East Asia, India and West Asia (A Study on the Beginnings of the "Food-Producing Stage"." In: S. B. Deo. (ed.) Archaeological Congress and Seminar Papers. pp. 95-106.

Sauer, C. O. 1952. Agricultural Origins and Dispersals. Bowman Memorial Lecture Series 2. American Geographical Society.

Savithri, R. 1976. "Studies in Archaeobotany Together with Its Bearing Upon Socio-Economic and Environment of Indian Protohistoric Cultures." Ph.D. Dissertation. Birbal Sahni Institute of Palaeobotany, Lucknow.

Savithri, R. and Vishnu-Mittre. 1978. "Setaria Species in Ancient Plant Economy of India." The Palaeobotanist. 25: 539-62.

Savithri, R. and Vishnu-Mittre. 1979. "Further Contributions on Protohistoric Ragi - Eleusine coracana." The Palaeobotanist. 26(1):10-15.

Saxena, S. K. 1979. "Plant Foods of Western Rajasthan." Man and Environment. 3:35-43.

Saxena, S. K. 1981. "Economic Plants of Indian Arid Zone." Man and Environment. 5:32-41.

Schaaf, J. M. 1981. "A Method for Reliable and Quantifiable Subsampling of Archaeological Features for Flotation." Mid-Continental Journal of Archaeology. 6(2):219-233.

Schwanity, F. 1966. The Origin of Cultivated Plants. Cambridge:Harvard University Press.

Sen Gupta, P. R. 1985. "The Geology and Geomorphology of the Indo-Gangetic Plain and the Emergence of the Harappan Culture." The Mankind Quarterly. 25(4):371-85.

Seth, S. K. 1963. "A Review of Evidence Concerning Changes of Climate in India during the Protohistorical and Historical Periods." In: Changes of Climate: Proceedings WMO/UNESCO Rome 1961 Symposium. pp. 443-54. UNESCO Arid Zone Research Series XX.

Seth, S. K. 1978. "The Dessication of the Thar Desert and its Environs during the Protohistorical and Historical Periods." In: W. C. Brice. (ed.) The Environmental History of the Near and Middle East during the Last Ice Age. pp. 279-305. London:Academic Press.

Shaffer, J. G. 1972. "Prehistoric Baluchistan: A Systematic Approach." Ph.D. Dissertation. Department of Anthropology, University of Wisconsin.

Shaffer, J. G. 1978. Prehistoric Baluchistan. Delhi:B. R. Publishers.

Shaffer, J. G. 1981. "The Protohistoric Period in the Eastern Punjab: A Preliminary Assessment." In: A. H. Dani. (ed.) Indus Civilization: New Perspectives. pp. 65-102. Islamabad:Quaid-i-Azam University.

Shaffer, J. G. 1982. "Harappan Culture: A Reconsideration." In: G. L. Possehl. (ed.) Harappan Civilization. pp. 41-50. Delhi:American Institute of Indian Studies.

Shaffer, J. G. 1984. "The Indus Valley, Baluchistan and Helmand Traditions: Neolithic Through Bronze Age." In: R. W. Ehrich. (ed.) Chronologies in Old World Archaeology. Forthcoming [3rd] Chicago:Chicago University Press.

Shaffer, J. G. 1986. "Cultural Development in the Eastern Punjab." In: J. Jacobson. (ed.) Studies in the Archaeology of India and Pakistan. pp. 195-236. New Delhi:Oxford and IBH.

Shaffer, J. G. 1988. "Reurbanization: The Eastern Punjab and Beyond." Studies in the History of Art. Special Symposium on "Urban Form and Meaning in South Asia: The Shaping of Cities from Prehistoric to Precolonial Times" Forthcoming:2-40.

Shaffer, J. G. In Press a. "One Hump of Two: The Impact of the Camel on Harappan Society." In: G. Gnoli. (ed.) Professor Giuseppe Tucci Felicitation Volume. Rome: IsMEO.

Shaffer, J. G. In Press b. "The Indus Valley Tradition." First International Conference on Pakistan Archaeology. Peshawar, Pakistan:Department of Archeology, University of Peshawar.

Shaffer, J. G. and D. A. Lichtenstein. 1987. "Ethnicity and Change in the Indus Valley Cultural Tradition." Forthcoming:1-22.

Sharma, A. K. 1982. "Excavations at Gufkral - 1981." Puratattva. 11:19-25.

Sharma, A. 1983. "Further Contributions to the Palaeobotanical History of Crops." Ph.D. Dissertation. Birbal Sahni Institute of Paleobotany, Lucknow.

Sharma, B. D. and Vishnu-Mittre. 1969. "Studies of Post-Glacial Vegetational History from the kashmir valley - 2. Baba Rishi and Yus Maiden." The Palaeobotanist. 17(3):231-43.

Sharma, C. and G. Singh. 1974a. "Studies in the Late Quaternary Vegetational History in Himachal Pradesh -1. Khajiar Lake." The Palaeobotanist. 21(2):144-162.

Sharma, C. and G. Singh. 1974a. "Studies in the Late Quaternay Vegetational History in Himachal Pradesh - 2. Rewalsar Lake." The Palaeobotanist. 21(3):321-38.

Sharma, Y. D. (ed). 1972. "OCP and NBP: 1971." Puratattva. 1971-72(5):1-100.

Sharma, Y. D. 1982. "Harappan Complex on the Sutleg (India)." In: G L Possehl. (ed.) Harappan Civilization. pp. 141-66. Delhi:American Institute of Indian Studies.

Shastry, S. V.. S and S. D. Sharma. 1974. "Rice." In: Sir J. Hutchinson. (ed.) Evolutionary Studies in World Crops: Diversity and Change in the Indian Subcontinent. pp. 55-62. Cambridge:Cambridge University Press.

Shaul, D. 1983. "Linguistic Models of Pueblo Prehistory." Paper Presented at the 11th Int. Confress Anthropological Ethnology Science, Vancouver.

Shaw, F. J. P. 1943. "Vegetable Remains." In: E. MacKay. (ed.) Chanhu-daro Excavations, 1935-36. pp. 250-51. New Haven:Amer. Oriental Series, 20.

Shaw, G. L. 1978. Flora of Gujarat State. Gujarat. Vallabh Vidyanagar:Sardar Patel University.

Shuster, R. and R. Bye. 1983. "Patterns of Variation in Exotic Races of Maize in a New Geographic Area." Journal of Ethnobiology. 3(2):157-74.

Singh, G. 1971. "The Indus Valley Culture Seen in the Context of Post-Glacial Climatic and Ecological Studies in North-West India." Archaeology and Physical Anthropology in Oceania. 6(2):177-89.

Singh, G. 1977. "Stratigraphic and Palynological Evidence for Desertification in the Great Indian Desert." Annals of the Arid Zone. 16(3):310-20.

Singh, G. and Agrawal, D P. 1976. "Radiocarbon Evidence for Deglaciation in Northwestern Himalaya, India." Nature. 260:232.

Singh, G. and Chopra, S K, and A. B. Singh. 1973. "Pollen Rain from the Vegetation of North-West India." New Phytologist. 72(1):191-206.

Singh, G. and Joshi, R D and A B. Singh. 1972. "Stratigraphic and Radiocarbon Evidence for the Age and Development of Three Salt Lake Deposits in Rajasthan, India." Quat. Res. 2(4):496-508.

Singh, G. and Joshi, R D, S. K. Chopra, and A. B. Singh. 1974. "Late Quaternary History of Vegetation and Climate of the Rajasthan Desert, India." Philosophical Transactions, Royal Society of London. Series B, 267(889)

Singh, U. V. 1962. "Excavations at Eran." Journal of the Madhya Pradesh Itihasa Parishad. 4:41-44.

Smart, T. L. and E. S. Hoffman. 1989. "Environmental Interpretation of Archaeological Charcoal." In: C. A. Hastorf and V. S. Popper. (eds.) Current Paleoethnobotany. pp. 167-205. Chicago:University of Chicago Press.

Sonawane, V. H., and R. N. Mehta. 1985. "Vagad - A Rural Harappan Settlement in Gujarat." Man and Environment. 9:38-44.

Sorghum: A Bibliography of the World Literature covering the Years 1930-1963. 1967. Biological Sciences Communication Project of The George Washington University. Metuchen, N.J:The Scarecrow Press, Inc.

Soundara Rajan, K. V. 1980. Glimpses of Indian Culture: History and Archaeology. Delhi:Sundeep Prakashan.

Soundara Rajan, K. V. 1984. "Kutch Harappan: A Corridor of the Indus Phase." In: B. B. Lal and S. P. Gupta. (eds.) Frontiers of the Indus Civilization. pp. 217-26. Delhi:Books and Books.

Spate, O. H. K., and A. T. A. Learmonth. 1967. India and Pakistan: A General and Regional Geography. [3rd Edition] London:Methuen.

Spector, J. D. 1970. "Seed Analysis in Archeology." The Wisconsin Archeologist. 51(4):163-190.

Steward, J. H. 1955. Theory of Culture Change. Urbana: University of Illinois Press.

Stewart, R. R. 1982. History and Exploration of Plants in Pakistan and Adjoining Areas. Karachi/Rawalpindi.

Struever, S. 1968. "Flotation Techniques for the Recovery of Small Scale Archaeological Remains." American Antiquity. 33(3):353-62.

Sullivan, A. P. III. 1987. "Seeds of Discontent: Implications of a "Pompeii" Archaeobotanical Assemblage for Grand Canyon Anasazi Subsistence Models." Journal of Ethnobiology. 7(2):137-53.

Swain, A. M., J. E. Kutzbach and S. Hastenrath. 1983. "Holocene Rainfall in India." Quat. Res. 18:1-17.

Thapar, B. K. 1969. "The Pre-Harappan of Kalibangan: An Appraisal of its Inter-Relationship." In: B. P. Sinha. (ed.) Potteries in Ancient India. pp. 251-56. Patna: Department of Ancient Indian History and Archaeology, Patna University.

Thapar, B. K. 1973. "Synthesis of the Multiple Data as Obtained from Kalibangan." In: D. P. Agrawal and A. Ghosh. (eds.) Radiocarbon and Indian Archaeology. pp. 264-71. Bombay:Tata Institute of Fundamental Research.

Thapar, B. K. 1975. "Kalibangan: A Harappan Metropolis Beyond the Indus Valley." Expedition. 17(2):19-32.

Thapar, B. K. 1978. "Early Farming Communities in India." Journal of Human Evolution. 7:11-22.

Thomas, D. 1973. "An Empirical Test for Steward's Model of Great Basin Settlement Patterns." American Antiquity. 38:155-76.

Thomas, K. D. 1979. "Palaeoecological Studies in the Bannu Basin: The Sources of Evidence." In: H. Hartel. (ed.) South Asian Archaeology 1979. pp. 227-32.

Thomas, K. D. 1983a. "Agricultural and Subsistence Systems of the Third Millennium B.C. in North-West Pakistan: A Speculative Outline." In: M. Jones. (ed.) Integrating the Subsistence Economy. Symposia of the Association for Environmental Archaeology No.4. pp. 279-314. BAR International Series 181.

Thomas, K. D. 1983b. "Tarakai Qila: Site, Economy and Environment." In: Proudfoot, B. (ed.) Site, Environment and Economy. Symposia of the Association for Environmental Archaeology No. 3:pp. 127-177. BAR International Series 173.

Toll, M. S. 1989. "Flotation Sampling: Problems and Some Solutions, with Examples from the American Southwest." In: C. A. Hastorf and V. S. Popper. (eds.) Current Paleoethnobotany. pp. 36-52. Chicago:University of Chicago Press.

Tosi, M. 1986. "The Emerging Picture of Prehistoric Arabia." Annual Review of Anthropology. 15:461-490.

Ucko, P. J. and G. W. Dimbleby. (eds.) 1969. The Domestication and Exploitation of Plants and Animals. Chicago:Aldine.

Ucko, P. J., R. Tringham, and G. W. Dimbleby. (eds.) 1972. Man, Settlement, and Urbanism. London:Duckworth.

Vats, M. S. 1940. Excavations at Harappa. 2 Volumes. Delhi: Government of India.

Vavilou, N. I. 1959. The Origin, Variation and Breeding of Cultivated Plants. New York:Ronald Press Co.

Vishnu-Mittre. 1961. "Plant Economy in Ancient Navdatoli-Maheswar." In: J. Clutton-Brock, Vishnu-Mittre and A. N. Gulati. Technical Reports on Archaeological Remains. pp. 13-52. Poona:Deccan College Publ. No. 2.

Vishnu-Mittre. 1963. "Pollen Morphology of Indian Amaranthaceae." Journal of the Indian botanical Society. 42(1):86-101.

Vishnu-Mittre. 1964. "On the Plio-Pleistocene Boundary in Northwest India." The Palaeobotanist. 12(3):270-76.

Vishnu-Mittre. 1965. "Floristic and Ecological Considerations of the Pleistocene Plant Impressions from Kashmir." The Palaeobotanist. 13(3):308-27.

Vishnu-Mittre. 1969. "Remains of Rice and Millets." In: S. B. Deo and Z. D. Ansari. (eds.) Excavations at Ahar (Tambavati) 1961-62. :pp. 239-36. Poona:Deccan College Post-Graduate Res. Inst.

Vishnu-Mittre. 1970. "Agriculture, Biological Concepts and Agriculture in Ancient India." Journal of History of Science. 5:144-66.

Vishnu-Mittre. 1971a. "Ancient Plant Economy at Hallur." In: M. S. N. Rao. (ed.) Protohistoric Cultures of the Tungabhadra Valley. pp. 125-33. India:Dharwar.

Vishnu-Mittre. 1971b. "The Lower Karewas." In: <u>Palynology of the Pleistocene and Holocene</u>. pp. 160-67. Novosibirsk, U.S.S.R:Proceedings of the 3rd Intern. Palynol. Conf.

Vishnu-Mittre. 1971c. "Plant Remains: Ancient Plant Economy at Hallur." In: M. S. Nagaraja Rao. (ed.) <u>Proto-Historic Culture of the Tungabhadra Valley</u>. :pp. 125-33. Dharwar

Vishnu-Mittre. 1972. "Palaeobotany and the Environment of Early Man in India." In: S. B. Deo. (ed.) <u>Archaeological Congress and Seminar Papers</u>. :pp. 206-212e. Nagpur: Nagpur University.

Vishnu-Mittre. 1974a. "Neolithic Plant Economy at Chirand, Bihar." <u>The Palaeobotanist</u>. 21(1):18-22.

Vishnu-Mittre. 1974b. "Palaeobotanical Evidence in India." In: Hutchinson. (ed.) <u>Evolutionary Studies in World Crops</u>. pp. 3-30.

Vishnu-Mittre. 1974c. "Plant Remains and Climate from the Late Harappan and Other Chalcolithic Cultures of India: A Study of Interrelationships." <u>Geophytology</u>. 4(1):46-53.

Vishnu-Mittre. 1976. "The Archaeobotanical and Palynological Evidence for the Early Origin of Agriculture in South and South East Asia." <u>Gastronomy</u>. :13-21.

Vishnu-Mittre. 1977. "Changing Economy in Ancient India." In: C. A. Reed. (ed.) <u>Origins of Agriculture</u>. pp. 569-87. The Hague:Mouton.

Vishnu-Mittre. 1978a. "Origins and History of Agriculture in the Indian Sub-Continent." <u>Journal of Human Evolution</u>. 7:31-36.

Vishnu-Mittre. 1978b. "Palaeoecology of the Rajasthan Desert during the last 10,000 Years." <u>The Palaeobotanist</u>. 25: 549-58.

Vishnu-Mittre. 1979a. "Ancient Food Economy in India with Remarks on the Aryan Hypothesis." <u>Ancient Ceylon</u>. 3-4: 379-87.

Vishnu-Mittre. 1979b. "Botanical Materials and Methods in Archaeology." <u>Ancient Ceylon</u>. 3:373-377.

Vishnu-Mittre. 1979c. "Environment of Early Man in North-West India: Palaeobotanical Evidence." In: S. R. K. Chopra. (ed.) <u>Early Man in North West India</u>. pp. 20-65. Bombay:Allied Publishers Private Limited.

Vishnu-Mittre. 1981a. "Botanical Perspective on the Quaternary." The Palaeobotanist. 28-29:402-412.

Vishnu-Mittre. 1981b. "Possible Significance of Pre-Neolithic Cereal Type Pollen in South Asia." Proceedings of the 4th Intern. Palyno. Conf., Lucknow (1976-1977). 3:291-94.

Vishnu-Mittre. 1982a. "The Harappan Civilization and the Need for a New Approach." In: G. L. Possehl. (ed.) Harappan Civilization. New Delhi:Oxford and IBH Publ. Co.

Vishnu-Mittre. 1982b. "Problems and Prospects of Palaeobotanical Approach Towards the Investigation of the History of the Rajasthan Desert." Proceedings of the Workshop on the Problems of the Deserts in India. Jaipur, September 16-18, 1975. Calcutta:Geological Survey of India, Miscellaneous Publ. No. 49.

Vishnu-Mittre. 1983. "Floristic Change in the Himalaya (Southern Slopes) and Siwaliks from the Mid-Tertiary to Recent Times." Typed Manuscript.

Vishnu-Mittre. 1984. "Quaternary Palaeobotany/Palynology in the Himalaya: An Overview." The Palaeobotanist. 32(2): 158-87.

Vishnu-Mittre. 1985. "The Uses of Wild Plants and the Process of Domestication in the Indian Sub-Continent." In: V. N. Misra and P. Bellwood. (eds.) Recent Advances in Indo-Pacific Prehistory. pp. 281-291. Delhi:Oxford and IBH.

Vishnu-Mittre and Gupta, H. P. 1976. "Pollen Analysis of Fossil Soils Along the Bank of the Ghod River, Inamgaon, Maharashtra." The Palaeobotanist. 23(1):72-77.

Vishnu-Mittre and Robert, R. 1973. "Pollen Analysis and Palaeobotany of Impression bearing Sediments in the Lower Karewas." The Palaeobotanist. 20(3):344-55.

Vishnu-Mittre and Savithri, R. 1975a. "Ancient Plant Economy at Inamgaon." Puratattva. 8:55-62.

Vishnu-Mittre and Savithri, R. 1975b. "Supposed Remains of Rice (Oryza sp.) in the Terracotta Cakes and Pai at Kalibangan, Rajasthan." The Palaeobotanist. 22(2):124-26.

Vishnu-Mittre and Savithri, R. 1982. "Food Economy of the Harappans." In: G L Possehl. (ed.) Harappan Civilization. :pp. 205-22. Delhi:American Institute of Indian Studies.

Vishnu-Mittre and Sharma, B. D. 1966. "Studies of Postglacial Vegetational History from Kashmir Valley - 1. Haigam Lake." The Palaeobotanist. 15(1-2):185-212.

Vishnu-Mittre and Sharma, C. 1975. "Pollen Analysis of Malvan, Gujarat." The Palaeobotanist. 22(2):118-23.

Vishnu-Mittre and Sharma, C. 1979. "Pollen Analytical Studies at Nal Lake, Gujarat." The Palaeobotanist. 26(1):95-104.

Vishnu-Mittre and Sharma, C., A. K. Saxena, K. Prasad, A. Bhattacharya and M. S. Chauhan. 1983. "Pollen Stratigraphy of India." Puratattva. 1981-83,13-14:115-121.

Wagner, G. E. 1983a. "Late Harappan Crops in Gujarat." Paper Presented at the 12th Annual Meeting of the Mid-Atlantic Region of the Association for Asian Studies, Philadelphia.

Wagner, G. E. 1983b. "Plant Remains from Oriyo Timbo." Unpublished Paper.

Wagner, G. E. 1985. "Botanical Remains." In: G. L. Possehl et al. Preliminary Report: Excavations at Rojdi 1983-84. Man and Environment Vol. IX.

Wagner, G. E. 1989. "Comparability among Recovery Techniques." In: C. A. Hastorf and V. S. Popper. (eds.) Current Paleoethnobotany. pp. 1-16. Chicago:University of Chicago Press.

Watson, P. J. 1976. "In Pursuit of Prehistoric Subsistence: A Comparative Account of Some Contemporary Flotation Techniques." Mid-Continental Journal of Archaeology. 1(1):77-95.

Weber, S. A. 1986. "The Development of a Society: An Introduction to the Special Issue." Journal of Ethnobiology. 6(1):iii-vi.

Weber, S. A. 1988. "An Evaluation of the Origin and Influence of Millets in South Asia." Paper Presented at the 11th Ethnobiology Conference, Mexico City, March 1988.

Weber, S. A. 1989a. "Accounting for Variability in the Temporal and Spatial Distribution and Occurrences of Plant Remains in South Asia Sites during the Second and Third Millennium B.C." Paper Presented at the Society for American Archaeology 54th Annual Meeting, Atlanta, Georgia. April 6, 1989.

Weber, S. A. 1989b. "Millets in South Asian Prehistory: Rojdi as a Case Study." In: M. Taddei. (ed.) South Asian Archaeology 1987. Forthcoming. Naples:IsMEO.

Werth, E. 1937. "Geography and History of Millets." Angewandte Botanik. 19:41.

West, J. 1976. "Plants Remains from Balakot, Las Bela District, Pakistan." Typed Manuscript.

Wetterstrom, W. E. 1976. "The Effects of Nutrition on Population Size at Pueblo Arroyo Hondo." Ph. D. Dissertation. University of Michigan.

Wetterstrom, W. E. 1978. "Cognitive Systems, Food Patterns, and Paleoethnobotany." In: R. Ford. (ed.) The Nature and Status of Ethnobotany. No. 67. pp. 81-96. Ann Arbor: Museum of Anthropology.

Wheeler, R. E. M. 1947. "Harappa 1946: The Defences and Cemetery R-37." Ancient India. 3:58-130.

Wheeler, R. E. M. 1968. The Indus Civilization. Supplement to the Cambridge History of India [3rd Edition] Cambridge:Cambridge University Press.

White, L. 1959. The Evolution of Culture. New York:McGraw-Hill.

Whyte, R. O. 1964. The Grassland and Fodder Resources of india. New Delhi:Indian Council of Agricultural Research.

Whyte, R. O. 1985. "Annual Crops of South and Southeast Asia." In: (V. N. Misra and P. Bellwood.) eds. pp. 259-274. [Recent Advances in Indo-Pacific Prehistory] New Delhi:Oxford and IBH Publ. Co.

Wing, E. and A. Brown. 1979. Paleonutition: Method and Theory in Prehistory Foodways. New York:Academic Press.

Winterhalder, B. and E. Smith. (eds.) 1981. Hunter-Gatherer Foraging Strategies: Ethnographic and Archaeological Analysis. Chicago:University of Chicago Press.

Wright, G. A. 1971. "Origins of Food Production in Southwestern Asia: A Survey of Ideas." Current Anthropology. 2(4-5):447-477.

Yarnell, R. A. 1964. Aboriginal Relationships Between Culture and Plant Life in the Upper Great Lakes Region. Anthropological Papers, Museum of Anthropology, University of Michigan, 23.

Yellen, J. E. 1977. Archaeological Approaches to the Present: Models for Reconstructing the Past. New York: Academic Press.

Young, B. 1910. "The Prehistoric Men of Kentucky." Filson Club Publication. 25.

Zohary, D. and M. Hopf. (eds.) 1988. Domestication of Plants in the Old World. Oxford:Clarendon Press.

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